Fine WoodWorking

GOOGLE SketchUp® Guide for Woodworkers

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Traditional Cabinets

By Timothy S. Killen

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Before We Begin . . .

More and more woodworkers around the world have adopted Google® SketchUp® as a new tool for the workshop. You see SketchUp used regularly in articles, books, plans, and drawings. Blogs and websites present tutorials on SketchUp, from basic training to highly advanced techniques. Woodworking clubs across the country and around the world now offer SketchUp training seminars.

It's no surprise that SketchUp has caught on quickly. Woodworkers want to improve their craft, acquire new skills, and tackle new and more challenging projects. SketchUp is just the tool to help meet those objectives, and it's free.

The application opens up new capabilities in 3D that were once available mainly to professional designers and illustrators with esoteric, hard-to-use, expensive computer-assisted design systems. No longer are you limited to two-dimensional shop drawings. Now, you can easily create a fully detailed 3D model made up of all the individual parts. You can also add wood-grain textures, shading, and other refinements to make your drawings very realistic.

Working in SketchUp entails doing a complete "build" on the computer before you begin real construction in the shop. As in real life, you asssemble the model a piece at a time, shaping and connecting individual components, complete with joint details, molding profiles, chamfers, and so on. You can create multiple views and drawings in SketchUp without having to spend time drawing the same thing repeatedly. You can easily generate conventional front, top, and side views; exploded views, like the one shown in Figure 2; as well as full-size templates and working drawings.

What this book offers you

This book builds on skills and techniques covered in my first book, *Google SketchUp Guide for Woodworkers.* That was one of the first books to show how SketchUp can be tailored to the needs of cabinetmakers. It covered basic SketchUp settings for efficient woodworking tasks. It went on to show how to use SketchUp to create basic furniture parts and joints, then showed more sophisticated features to create complex models. It also showed how to assemble effective packages of shop drawings.

This book focuses on mastering SketchUp for a specific furniture form—cabinets. This is a broad, popular category that covers many styles, sizes, uses, and shapes.

I will show you how to create three representative styles of cabinets, ranging from fairly simple to quite complex; together, they embody most of the design and structural considerations that go into any sturdy, atractive, well-made cabinet.

The SketchUp models will be worked thoroughly, down to the last detail. You won't have to guess about joinery details, how doors are made, or how the back panel fits in place. The design detail will be comprehensive and complete.

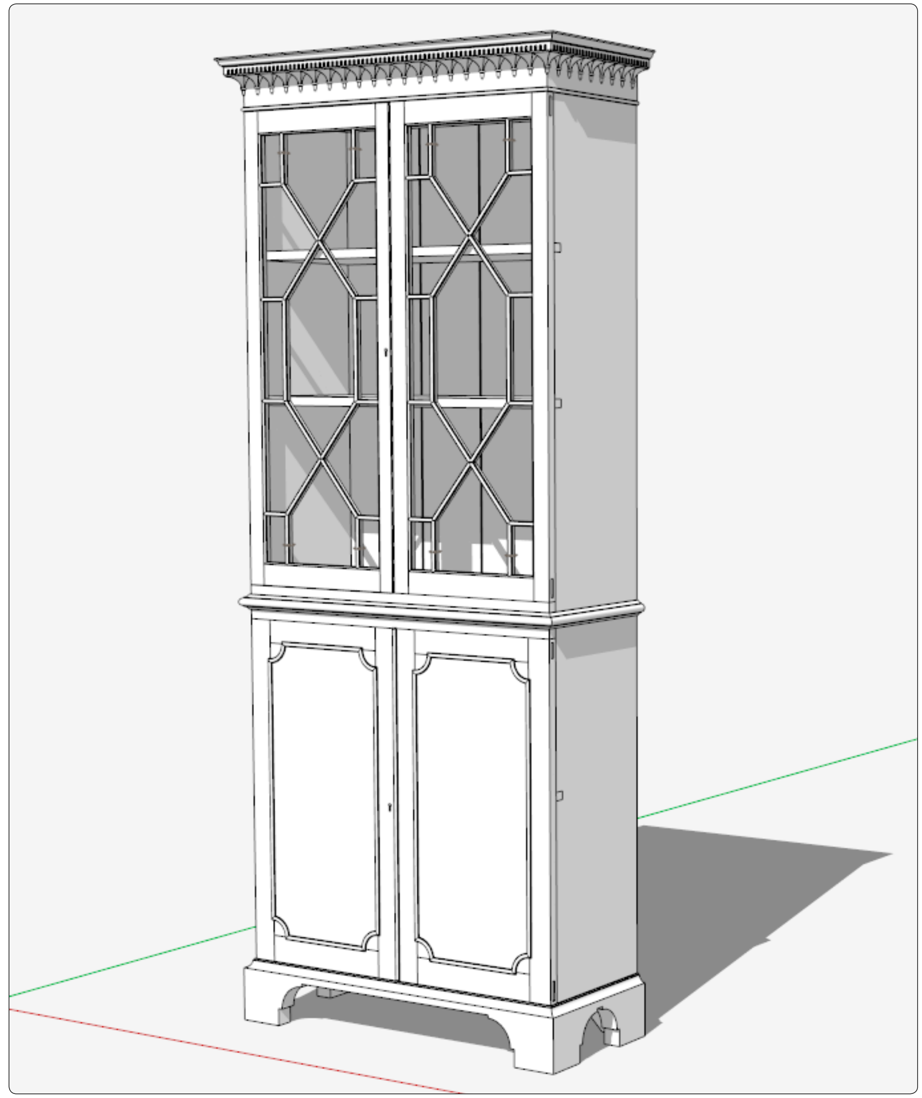


Figure 1. *A 3D view of an 18th-century cabinet in SketchUp. Like the real cabinet, the drawing is made from components for each board and strip of molding, complete with all the joinery details.*

Working through these three case studies in SketchUp on your computer will help you to internalize these design and construction considerations, so that when you take on a new project, you can apply the tools and knowledge you learn here.

My hope is that this book will help you in these four ways:

- To develop a general knowledge of cabinet design and construction.
- To become familiar with 3D design, which will improve your woodworking.
- To show you how to customize existing SketchUp models.
- To show you how to create detailed design documents, making the actual shop work more efficient.

This book is not about how you do the physical construction in the shop and what power or hand tool techniques you should use. There are plenty of other resources for that. Instead, I'll detail the steps and tools required to "build" the piece in SketchUp.

Contents of this book

This book addresses the needs of professionals and hobbyists who are cabinetmakers, furniture designers, woodworking teachers and students, and home craftsmen.

It begins with a review of the tools, features, and procedures you need to know to use SketchUp for woodworking. From there, it shows how to design and draw cabinets in SketchUp and outlines the basic anatomy and engineering of cabinets.

The heart of the book are the plans and detailed instructions for creating three styles of cabinets:

- A Shaker-style wall cabinet with dovetail and mortise-and-tenon joinery.
- An Arts-and-Crafts display cabinet with leaded-glass doors.
- An 18th-century period reproduction of a corner cupboard.

In addition to explaining how to create precise joints and moldings, the book also shows how to design hinges, latches, and pulls. It also shows you how to develop a comprehensive package of shop drawings and how to modify an existing SketchUp design to create a new piece.

The book includes numerous computer-screen illustrations and annotated photos, as well as videos showing key SketchUp procedures. Each chapter is divided into sub-sections, many introduced with a video of the steps involved in that section. I recommend watching the video first, then working through the step-by-step instructions that follow.

Accompanying this book are actual SketchUp files, models, and components. You can use these resources to create your own new cabinet designs, resizing, embellishing, and shaping these already drawn SketchUp components and assemblies to suit your own needs.

I use the Pro Version of SketchUp, which sells for about $500. It has functions that I use in my work and teaching. However, you can be assured that the free version of SketchUp has all the features you need to produce the most complex woodworking projects and comprehensive shop drawings. Go to sketchup.google.com for the download.

There are a handful of places in this book where I will point out a feature available only in SketchUp Pro. Otherwise, you will be able to replicate the steps and actions I show in this book using the free version.

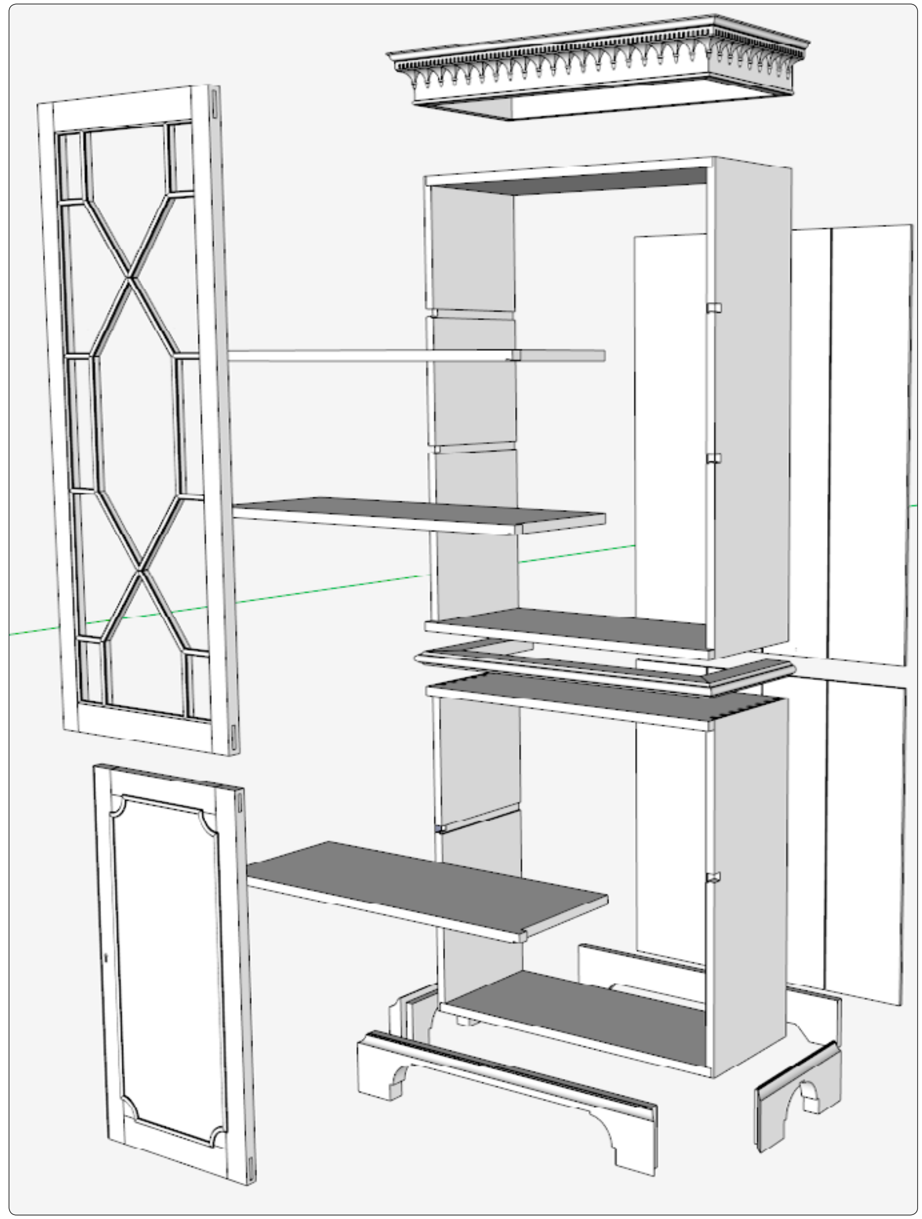


Figure 2. *An exploded view of the 18th century cabinet. Exploded views are easily created in SketchUp without any redrawing. You simply reposition the original components you created.*

Brushing Up on SketchUp

This chapter summarizes some of the most critical tools and features you will need to know to model woodworking projects in SketchUp. It is not meant to be a comprehensive resource for people who are new to SketchUp. If you feel you need more basic training before you begin drawing cabinets, read my first book, *Google SketchUp Guide for Woodworkers* (Taunton Press, 2010). Or, tap into other help and training resources recommended by Google (see http://sketchup.google.com/support/?hl=en).

Set Up for Woodworking

Like many computer applications, SketchUp can be customized in many ways. After all, many different types of professionals use SketchUp, each with his or her own modeling environment and processes.

Here's how I have customized SketchUp for my modeling.

Customize a Template SketchUp has built-in templates for several specialties, such as architecture and engineering. You can see them all when you first download the application and view its Welcome screen. Click the button labeled Choose Templates and select Product Design and Woodworking. See Figure 3. (You can always get back to the Welcome screen by clicking on Help in SketchUp's menu bar and then selecting Welcome to SketchUp.)

This template makes a good starting point, but you will want to customize it with some alternative settings. You can change the units of measure, the way dimensions are displayed, the size and typeface for text and numbers, and other variables.

Click on the Window tab in the menu bar, then select Model Info. The Model Info dialog box displays a list of the properties you can modify in a panel at the left of the screen (Figure 4).

After you make the modifications, save the template as your default. Click on File in the SketchUp menu bar and choose Save as a Template. Every time you open SketchUp, you will be working in that template.

Modify the Style Settings These determine the background color in your drawings, the weight of the lines that form the edges of objects in the drawings, and the colors of the objects you draw. To get to the Style settings, click on the Window tab in the menu bar and choose Styles to open a new window.

I use different styles in my drawings: one for the normal view, another for X-Ray view, and a third for Back Edges view (this shows hidden parts with dashed lines, as in conventional mechanical drawings). I usually keep the drawing background on the bright side—not entirely white, but with a little gray. The profile of my Edges is set to 1. Otherwise, I mainly stick with the default values (Figure 5).

Arrange the Toolbars and Dialog Boxes Toolbars are selected from the View tab on

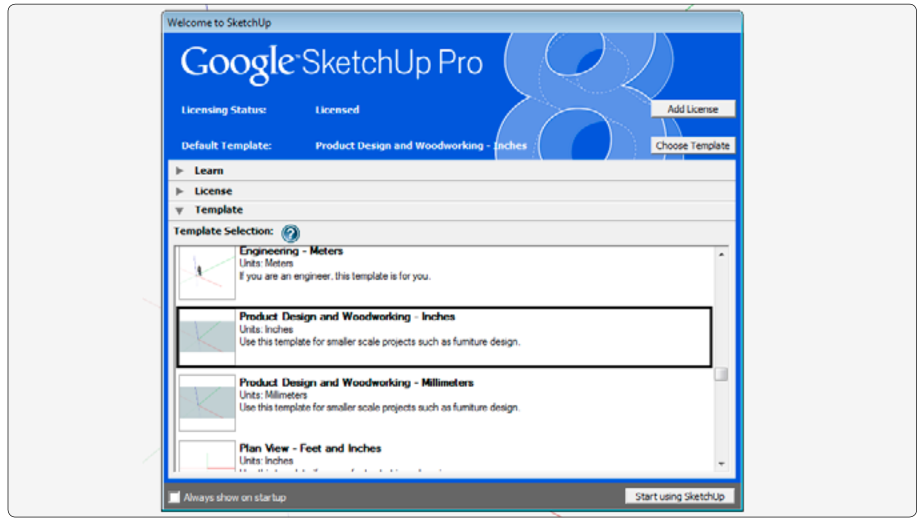


Figure 3. *The SketchUp Welcome screen.*

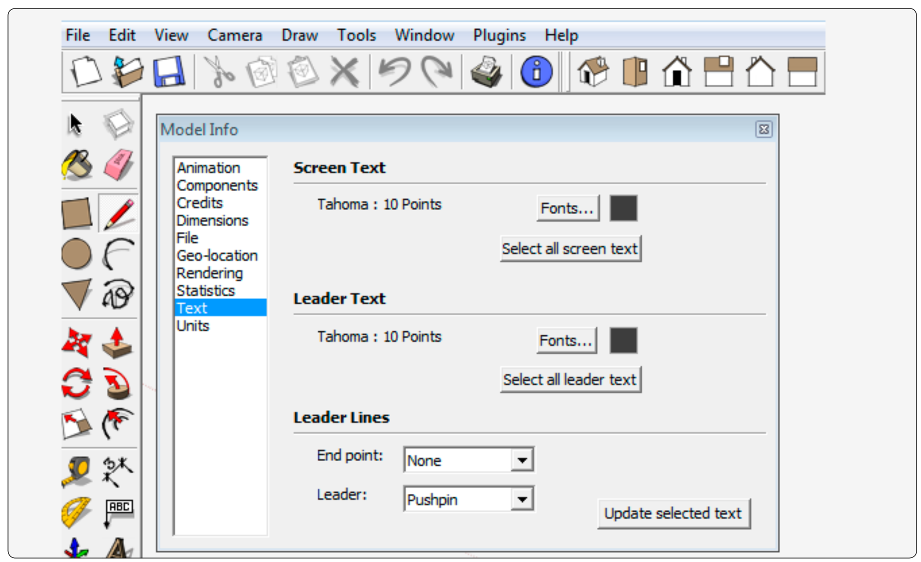


Figure 4. *The Model Info dialog box.*

the menu bar. I recommend selecting these toolbars from the list: Large Tool Set, Style, Layer, Standard, and Views (Figure 6).

After selecting those toolbars, you should see a check mark in the list next to their names. You can unselect any other toolbars that have a check mark in the list.

I also maintain a set of dialog boxes on the screen at all times. I keep them in a "minimized clump" format. I like to have the Materials, Components, Styles, Layers, and Scenes dialog boxes in the clump, so I can open them without having to work through drop-down menus. The boxes are all available from the Window drop-down menu.

You can see a picture of my normal SketchUp setup in the screen shown in Figure 9.

How to Move Around the Model

There are three basic movements in SketchUp: zoom, orbit, and pan. While there are tool icons in the Toolbar for each of these functions, I strongly suggest that you avoid using them. Instead, do all the moving and zooming with a mouse that has a scroll wheel. The reason is simple: A mouse lets you multitask. You can be drawing a line, moving a component, or copying it while simultaneously moving around the model. You don't have to stop one activity and switch tools when you want to shift your view of the model.

Efficient movement around the model is one of the most important skills to develop in SketchUp. Good modeling necessitates changing your point of view to ensure accurate connections, placements, and movements. This requires you to continually orbit, zoom, and pan around the model.

This is another instance of SketchUp mimicking real shop work. You sometimes stand across the room to take in the entire piece you are building; other times, your nose may practically touch the wood so you can work on a small detail.

Multitasking with the mouse may take some practice, but it is one of the most important modeling skills you must master.

Become Familiar with Toolbars

You'll want to be familiar with the toolbars in the SketchUp screen (Figure 8).

Standard Toolbar This is the first one on the left in the line of toolbars at the top of the screen. The icons identify functions that are common to many computer applications.: Cut, Copy, Paste, Print, Undo, Redo, and the like. The Apple Macintosh® version lacks the Standard Toolbar, but you can pick the Undo/Redo Toolbar, which is very helpful. I probably use the Undo more than any other function.

Views Toolbar The six icons represent standard views in SketchUp. They let you reorient the entire model with one mouse click. Views are useful when creating top, front, or side orthographic views of specific components of the assembled model.

Styles Toolbar The seven icons in this toolbar determine the appearance of the model. The default face style is the second from the right: Shaded with Textures. I find it effective for most of modeling. The only other two styles I use are X-Ray and Back Edges.

Layers Toolbar As you begin to learn SketchUp, I think it is best to ignore the Layers tools. Although CAD programs typically require the use of different layers, SketchUp doesn't. However, I find that the Layers toolbar helps when I add dimensions to a model. I'll cover this in the last chapter.

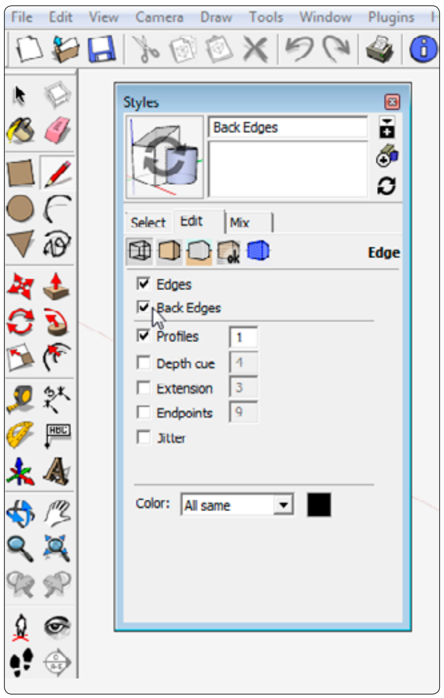


Figure 5. *The Styles dialog box for the Back Edges view.*

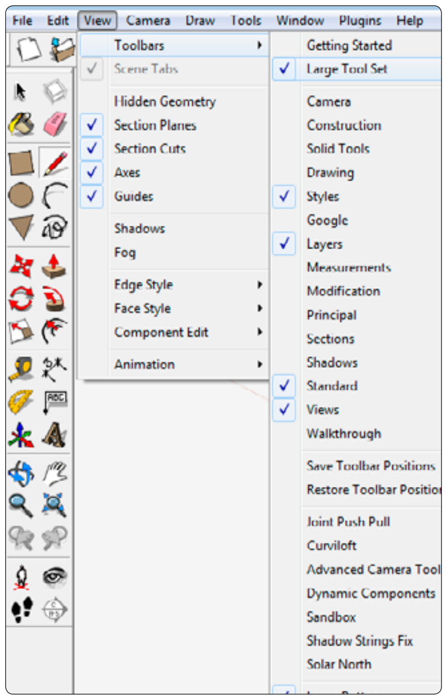


Figure 6. *Selecting Toolbars from the View drop-down menu.*

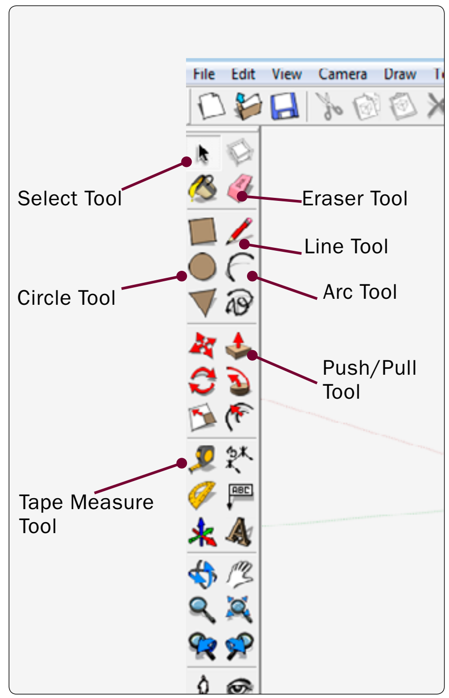


Figure 7. *The basic drawing tools in the Large Tool Set.*

Large Tool Set This vertical array of icons on the left edge of the screen includes all the drawing, moving, measuring, and labeling tools. Here you have the Line, Eraser, Push/Pull, Select, Rectangle, Circle, Arc, and Tape Measure. These are all the frequently used drawing tools and the first ones that you should learn to use (Figure 8). If you need help with any of them, review Chapter 4 of my previous book.

Two of those tools are especially useful for woodworking models:

- The Push/Pull Tool transforms a plane or face into a 3D object. It allows you to make mortises and tenons and to make or change the thickness, width, or length of a piece of wood. The Push/Pull Tool only works on flat faces and will not move, reshape, or change a curved surface.
- The Tape Measure is another unique and frequently used tool. You can use it to check dimensions. More important, it lets you place temporary construction lines to show the location of holes, dovetails, joints, cuts, grooves, and so on.

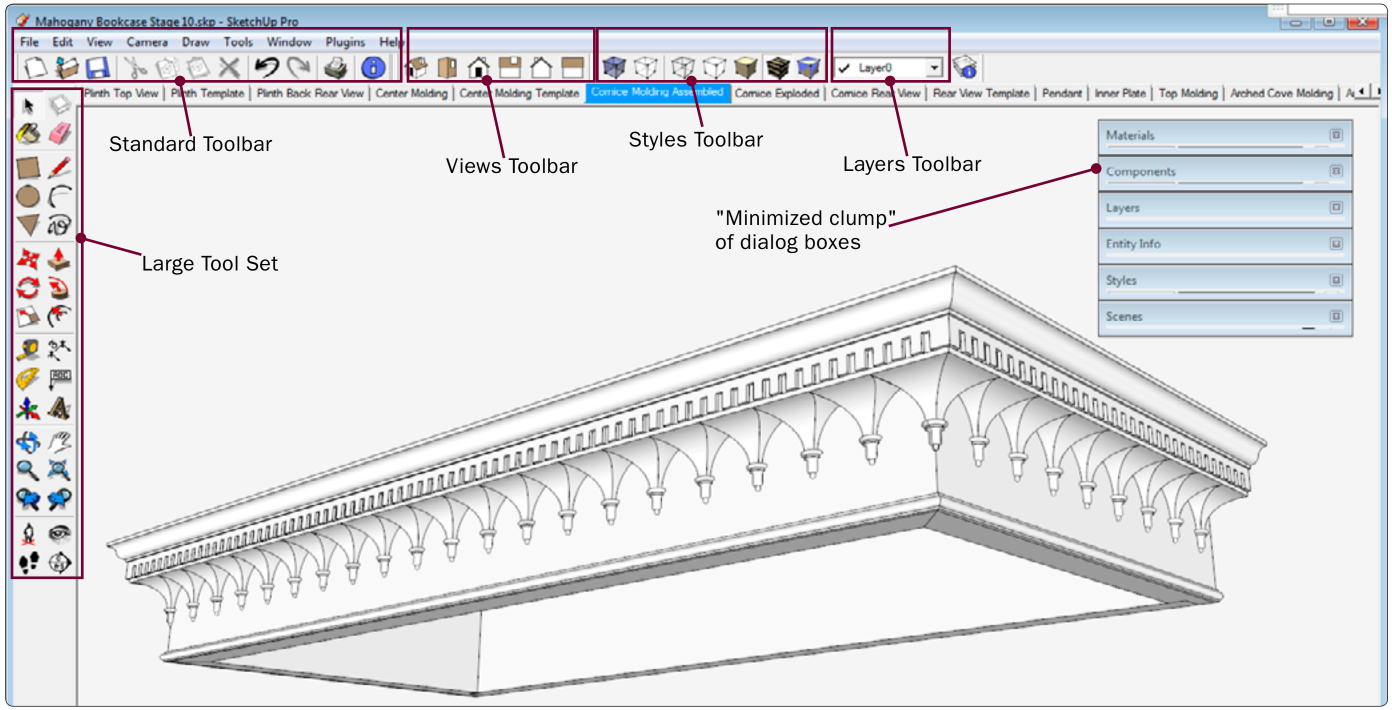


Figure 8. *My SketchUp set-up, Toolbars, and clumped dialog boxes. The model on display is a close-up view of the crown molding assembly in the 18th-century cabinet. It is made up of more than 50 parts, including the small turned acorn pendants.*

Mind the Axes

When drawing cabinet components and assembling models, you always need to keep in mind how SketchUp's axes are aligned. When you first open SketchUp, all you see are blue, red, and green lines meeting at the origin point (Figure 9). The red axis follows the X direction (left to right); the green axis, the Y direction (from front to back); and the blue axis, the Z direction (up and down).

As a rule, if you don't stay on axis, you will not be able to create proper 3D shapes. Fortunately, SketchUp automatically helps keep you properly oriented by highlighting an axis color when you use one of the drawing tools. For example, when you begin drawing a line without regard to its axis, the line will appear black; when you get the line oriented along, say, the X axis, the line will change to red. Success with SketchUp depends greatly on your ability to draw lines, arcs, and circles with respect to these axes. The sidebar on page 6 explains other ways to stay on axis.

Learn to Draw Precisely

Woodworking requires accuracy and precision in drawings and plans. In SketchUp, the surest, most efficient way to ensure accuracy is to rely on the Measurements Box, located in the lower right-hand corner of the screen. As you use different drawing tools, the values shown in the box change to tell you exact line length, circle radius, arc bulge, rectangle size, distance moved, angle rotated, and protractor angle. The label to the left of the box changes to tell you what value will be shown.

SketchUp controls the Measurements Box and decides what parameters are applicable for the specific tool or action you want to do. You cannot click to enter the box or force it to change parameters. However, with most drawing tools you can select the tool, begin using it, and type a value that will appear in the Measurements Box and generate the line, arc, or angle you want.

For example, if you want a line that is exactly 2½ in. long, you select the Line Tool and begin drawing. Type 2½ and press Enter. SketchUp generates a line of that exact length. See Figure 10.

Learn to Handle Components

One of SketchUp's most important features is the Make Component function. Woodworkers create, move, connect, copy, and modify furniture or cabinet parts. Compo-

nents are the SketchUp equivalent—legs, stretchers, tops, drawer fronts, knobs, rails, stiles, panels, slats, arms, seats, and so on. When you add a mortise to a leg in SketchUp, you are editing a component called "leg," which is an integrated object, not a bunch of individual edges, lines, and graphical entities. You can touch the leg (using the Select Tool), and move, copy, and change it as if it were a real piece of wood.

Components are essential for success in SketchUp. Without them, all you have are a bunch of lines and faces that interact and interfere with one another. There is no other way to work with the model: You must create pieces (components) that represent each part of the cabinet assembly.

Components also add considerable speed, efficiency, and accuracy to your modeling. When you make a change in one copy of a component, the same change instantly appears in all copies of that component. For example, when you draw dovetail tails for the corner joint in one side of a cabinet, SketchUp instantly generates identical tails in the other side component.

How to Make a Component It is best to create components right away when you begin a model, even before the "piece of wood" is entirely shaped with moldings, joints, or other embellishments. This will make your modeling more efficient and accurate.

To make a component, draw a left-to-right selection box around all the edges and faces that represent the lumber piece. The selected items will change to blue. Right-click on the selection and choose Make Component from the pop-up menu. This will open another dialog box, asking you to name the

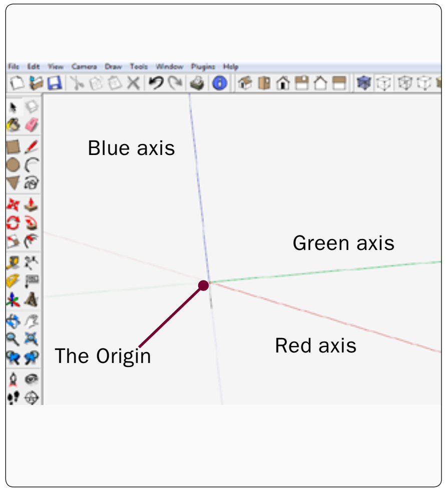


Figure 9. *The axes.*

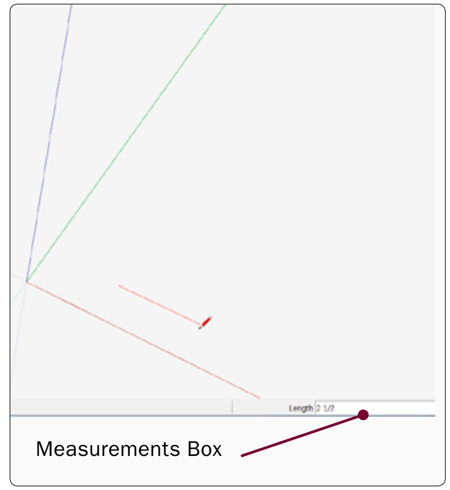


Figure 10. *The Measurements Box.*

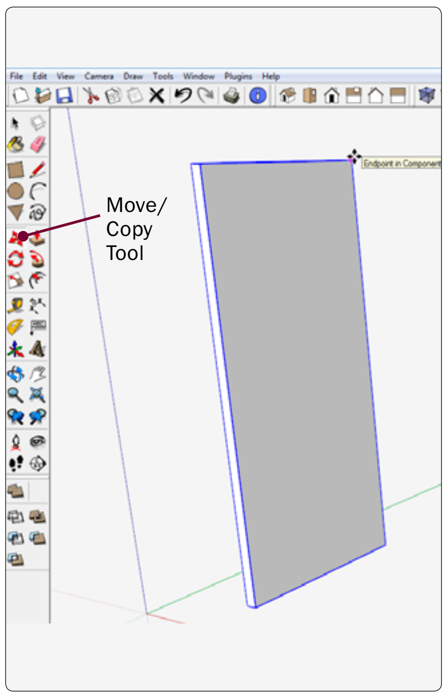


Figure 11. *Moving a component.*

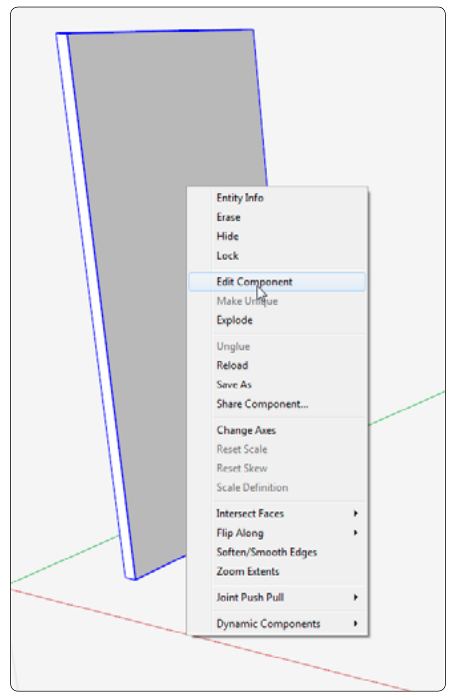


Figure 12. *Editing a component.*

Use the Arrow Keys to Stay on Axis

It's important to use SketchUp's two techniques to help you stay on axis. I use both of them very frequently.

One relies on the arrow keys on the computer keyboard.

Tapping the appropriate key when you begin to draw a line constrains the line to a particular axis. For example, if you want to draw a line on the red axis, click the mouse to begin the line, then tap the right arrow key. No matter what direction you move the mouse, the line will follow the red axis. To constrain the line to the green axis, tap the left arrow key. To constrain the line to the blue axis, tap the up or down arrow keys.

The arrow keys also work with the Move/Copy Tool. To constrain movement of a component on the red axis, for example, tap the Right Arrow key. Use the other arrow keys to constrain movement on the other axes.

The other technique for constraining movement involves using the shift key. Begin drawing a line or moving a component along the desired axis, then hold down the shift key. This constrains the line or movement on that axis.

You will find these techniques invaluable.

component. Enter a name. Be sure the box labeled Replace Selection with Component is checked. Click the button labeled Create.

How to Move a Component Use the Move/Copy Tool (Figure 11) to maneuver components around in the model. Choose the Move/Copy Tool and move the cursor over the component. This automatically selects the component. Figure 11 shows the screen when I hovered over the upper front corner of the component. I find that it's best to move a component by latching on to one of its corners, especially when you need to connect two components corner to corner.

How to Copy a Component The Move/Copy Tool also allows you to copy a component. Choose the tool and hover over the component. Press the keyboard Ctrl key (Option on Macs). A small plus sign will appear next to the cursor, indicating that you're making a copy.

Click on the component and begin to move the mouse. You will see a copy of the component move as well. Click the mouse button to stop the movement.

How to Edit a Component With any of the drawing tools selected, you can right-click on the component. Select Edit Component from the pop-up menu. which will expose a pop-up list (Figure 12).

When you open a component for editing, SketchUp places a dotted-line box around the component. All other components are paled out. This tells you that only the selected component is ready to be edited. You can then add joint details, chamfers or other edge details, or alter the component's shape without affecting any other component.

When you have finished editing, right-click on an area of the model away from the box around the selected component. This will open a small pop-up box; choose Close Component from the list.

More Tools and Functions

For comprehensive modeling and more complex woodworking projects, you'll need to understand how to use additional tools (Figure 13) and functions. Here are seven.

Flip Along This function is very effective in furniture modeling because you continually have to flip, or mirror, components. Consider a cabinet carcase, for example. It has two identical sides that are mirror images of each other. It's extremely powerful and time-saving to draw only one side, then copy and flip it to create its mate, with all the joinery properly oriented. If I edit either side component, the copy is instantly updated with the changes, all properly oriented.

Figure 14 shows the process of flipping a copy of a component. Right-click on the copied side and pick Flip Along from the pop-up menu. Another small menu appears, asking for a selection of red, green, or blue axis. In this case, red is the proper choice.

Protractor Tool You use this tool to place angled guidelines. This is handy when creating miter joints, dovetails, wedges, and other angled features. When you select this tool, the cursor changes to a circular protractor shape. You click the tool on the component and move the mouse to lock on to one of the reference axes. Click the mouse to begin the rotation. You can now type the angle value and press Enter to place the guideline.

Follow Me Tool Moldings as well as beveled and turned components are essential to furniture, particularly cabinets.

To make those elements in SketchUp, you use the Follow Me Tool. This tool extrudes shapes along a defined path, even if it curves or changes direction. (To add a molding profile or bevel to the edge of a straight piece, the Push/Pull Tool will work fine.)

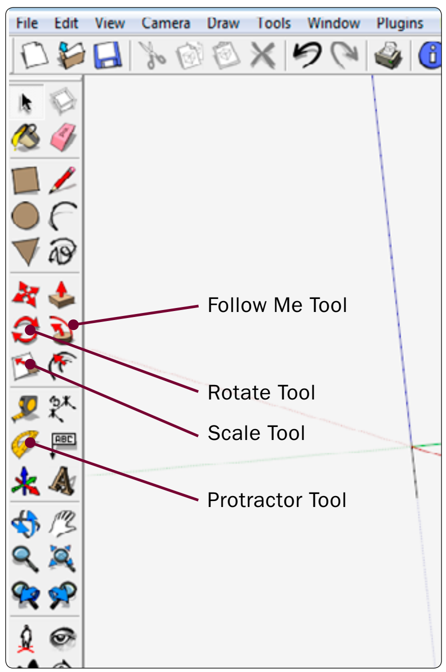


Figure 13. More drawing and moving tools.

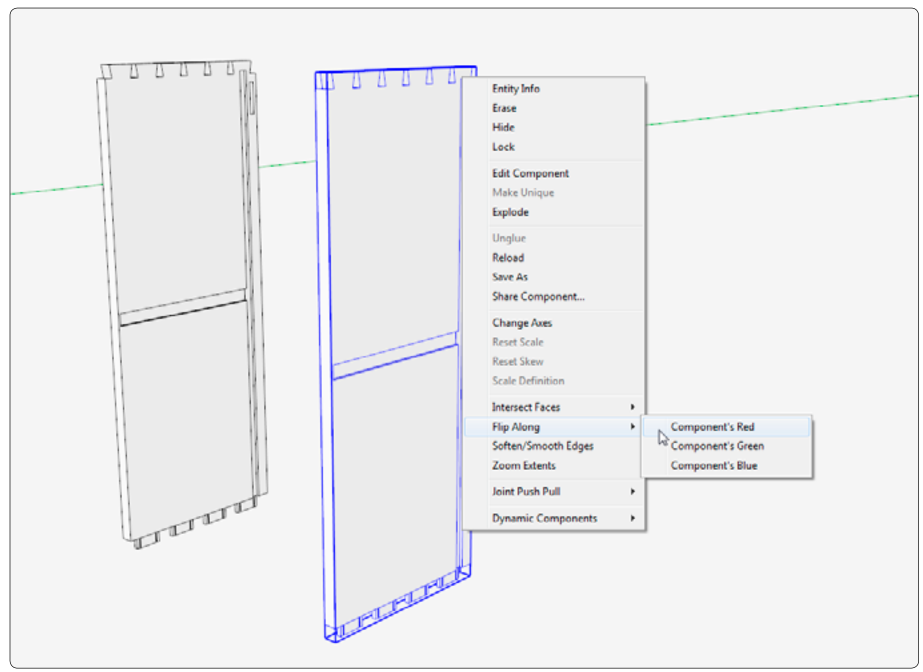


Figure 14. Using Flip Along to create the mirrored side component.

To use the Follow Me Tool, first create the specific profile to be extruded or routed. Then make a path with the Line, Arc, or Circle Tools. You can also define a path by selecting individual edges in the blank pieces to be shaped. Highlight the path with the Select Tool, select the Follow Me Tool, and click on the face of the profile shape.

For turnings, the path is a circle. A half-profile shape is lined up on the circle's axis (Figure 15).

Intersect In SketchUp you can connect different shapes and find their intersections. As an example, consider the cabinet door. The muntins connect in sockets within the beaded edge of the door stiles and rails, as shown in Figure 16. You use the Intersect function to create all the angled faces in the muntin ends and their corresponding sockets.

You create faces with the Line Tool and place them where you want the 45-degree cuts (Figure 17) so they overlap part of the muntin. Next, you "explode" the components, meaning you undo them as separate entities.

Next, right-click on the muntin and angled face and select Intersect Faces With Selection from the pop-up menu. After the intersect, there will be waste faces and edges that you must delete with the Eraser Tool. You will be left with a perfect fitting V-cut in the end of the muntin. You have to make it a component again.

The Scale Tool Intersection and extrusions aren't always rendered well when you try to create small-scale furniture parts. In those situations, you have to use SketchUp's Scale Tool to enlarge the component to 10 or 100 times its actual size. Once you've completed work on the component, rescale it to its original size.

You might think the Scale Tool would make it easy to resize furniture assemblies. Suppose, for example, that you have an existing model of a cabinet, but you would like one that's three-quarter-size. Using the Scale Tool, you can create a three-quarter-size cabinet with just a few mouse-clicks. But all dimensions are reduced by a factor of one fourth. That almost always produces inappropriate changes in lumber thicknesses and joint sizes.

I will cover more effective ways of scaling furniture parts in Chapter 6.

The Rotate Tool You can use the Move/Copy Tool nearly every time you need to rotate a component. But when you're working with angled parts that are not to be rotated on SketchUp's axes, you need the Rotate Tool. I also use the tool to accurately adjust the orientation of an imported scanned image. These images are usually askew and require slight nudges to align them with the SketchUp axes.

Soften/Smooth Edges. Intersections and Follow Me commands almost always produce extraneous lines along curved surfaces.

SketchUp's Soften/Smooth Edges function will hide those lines. To use it, select the component, right-click, select Edit Component from the pop-up menu, and select all surfaces. (Or triple-click on the component.)

Right-click on the selected component and choose Soften/Smooth Edges from the pop-up menu.

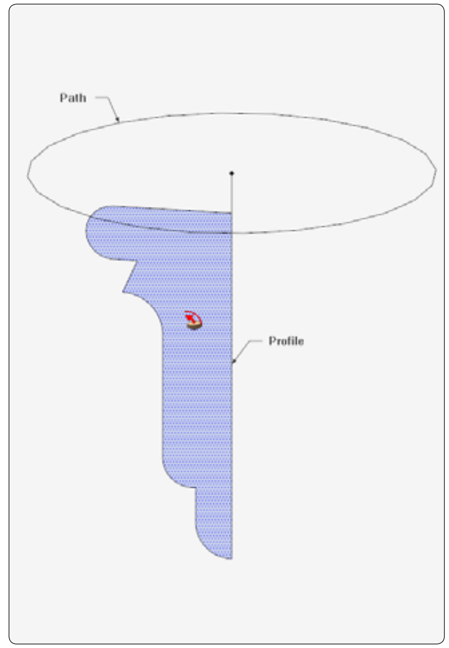


Figure 15. *Turning with the Follow Me Tool.*

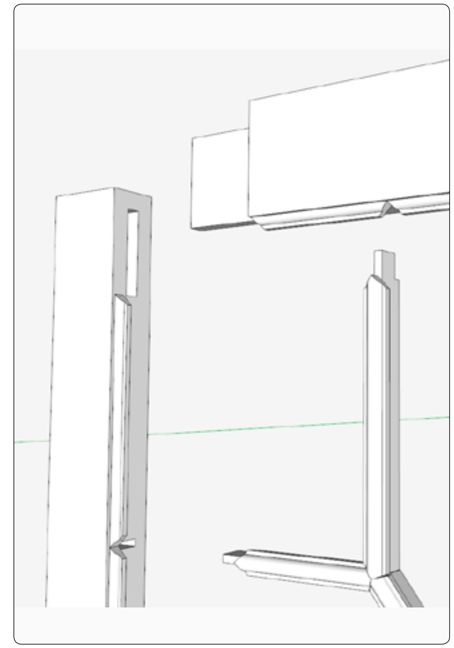


Figure 16. *Muntin connections.*

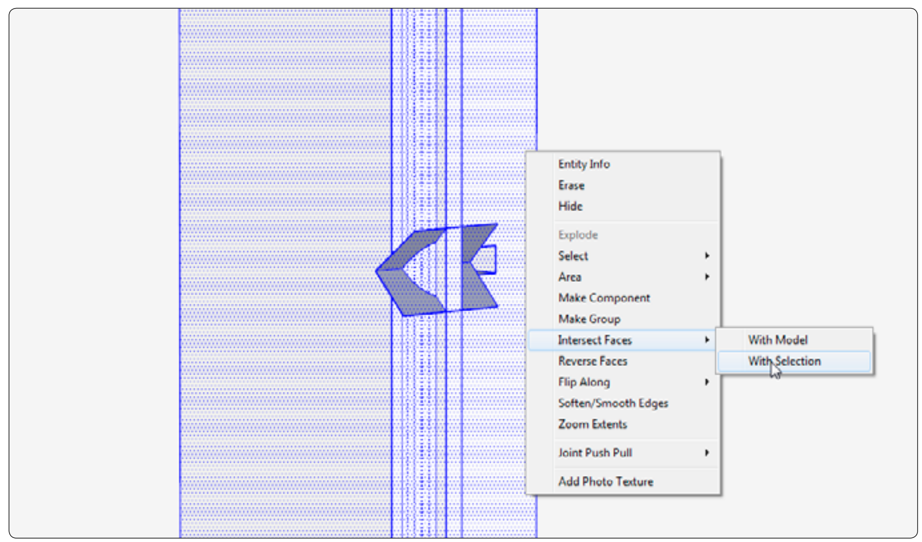


Figure 17. *Cutting the sockets in the stile using the Intersect function.*

Cabinet Types and Structures

The word cabinet means many things. I suspect that most people equate cabinets with the ones in the kitchen or bathroom. An office worker may add filing cabinets to the list, but that's about it. Those are certainly the most prevalent cabinets today, As the sidebar below explains, however, cabinets include many types, sizes, and purposes.

In the next chapters, I'll show in detail how to model three specific cabinets in SketchUp. These three cases are classics, covering the period from the late 18th century to the early 20th century and embodying three different styles: Period, Shaker, and Arts and Crafts. But despite their very different appearance, they have much in common. The lumber is solid wood fastened with mortise-and-tenon joints and dovetails. You won't find plywood, biscuit joints, pocket screws. or other new-fangled materials and fasteners in these pieces.

Anatomy of a Traditional Cabinet

Before you become immersed in the details of the three projects in the heart of this book, it will help to review some basics of cabinet construction and terminology.

The piece I've chosen to represent the traditional cabinet is a Colonial cupboard featured in an article in the October 2001 issue of *Fine Woodworking* magazine. See Figure 2. The author, Mike Dunbar, reproduced a late-18th-century original.

I have used this piece, slightly modified, in an adult-education class I teach (see the

Cabinet? Cupboard? What's in a Name?

Both Webster's and the Oxford English Dictionary define a cabinet as a cupboard or case with drawers, shelves, and the like for storing or displaying things.

So the definition of cabinet includes the word cupboard. The dictionaries say that a cupboard is a piece of furniture with a door and shelves, or a cabinet with shelves, used to store cups, plates, food, and such.

"Cabinetmaking and Millwork," by Dahl and Wilson, defines cabinet as "a chest or a case, such as a set of drawers or a cupboard, fitted with shelves, drawers, or both, used to store various articles."

In his "Furniture Treasury," Wallace Nutting says the word cabinet is "Strictly used for a carcase having doors and drawers or divisions behind them. Cabinet is distinguished from a chest, the latter having no drawers at the top, and from a cupboard in which the matter of drawers is secondary, and from a chest of drawers which has no doors."

So it seems then: All cupboards are cabinets, but not all cabinets are cupboards.

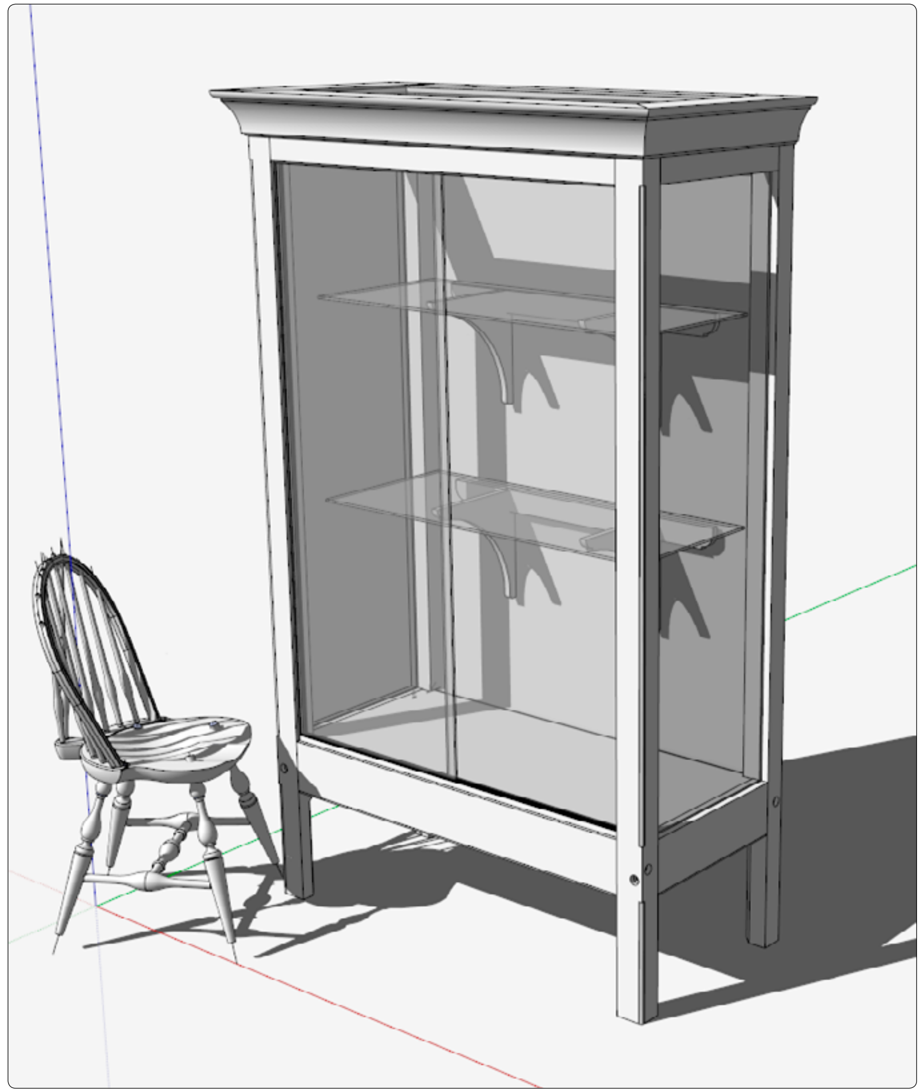


Figure 1. *A large display cabinet with glass sides and top and sliding-glass front doors. The Windsor chair is shown to illustrate the scale of the cabinet.*

sidebar on page 11). After covering the construction of the Colonial cupboard in detail, I'll show how some other cabinet designs embody alternatives.

Figure 3 shows an exploded view of the cupboard's main components or sub-assemblies. These parts, which you expect to see in just about any cabinet, include:

- Carcase.
- Face frame.
- Plinth or bracket base.
- Cornice molding,
- Back panel.
- Frame-and-panel door.

Carcase The carcase or case (Figure 4) consists of the sides, top, shelves, and bottom. These parts are often dovetailed at the corners to create a very strong box. The dove-

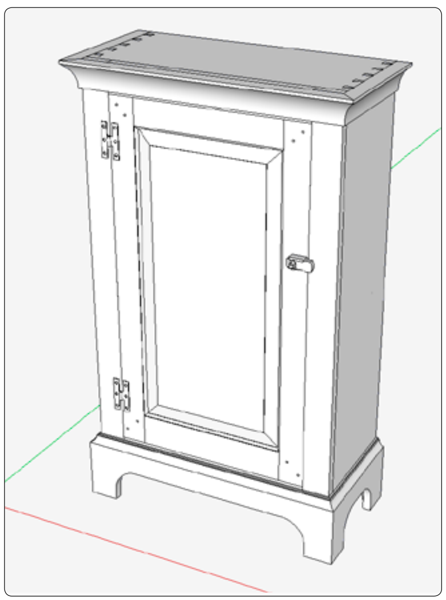


Figure 2. *Small Colonial cupboard.*

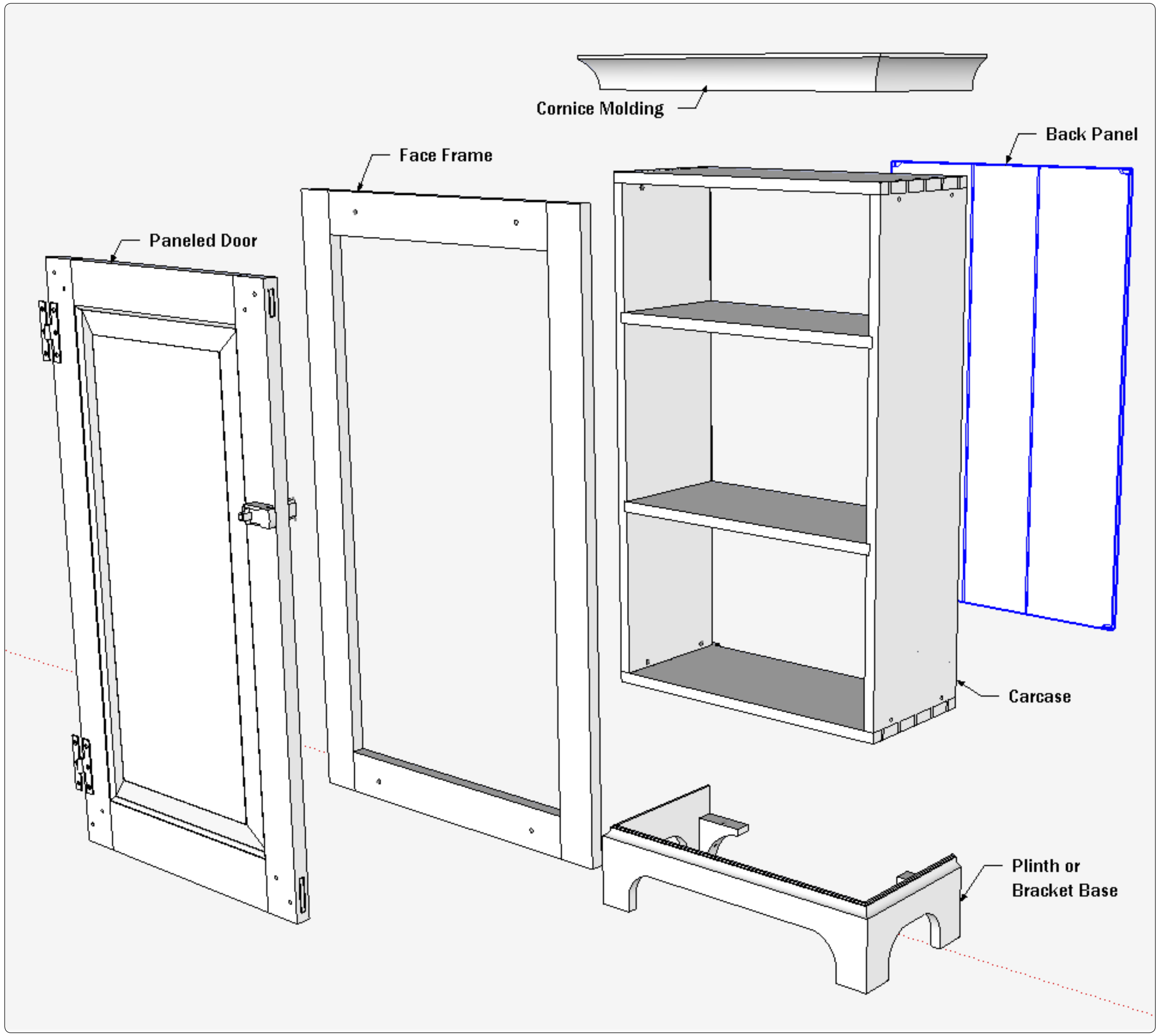


Figure 3. *The main subassemblies of the Colonial cupboard.*

Cabinets in the Classroom

In March 2007, I began teaching an adult education course on building classic furniture. This course was conducted in 10 three-hour sessions in a well-equipped workshop in Pleasant Hill, California.

The challenge for me was selecting a piece that each student could reproduce within a 30-hour time frame, yet provide sufficient complexity in construction.

I settled on a small cabinet, a Colonial cupboard reproduced by Mike Dunbar and described in the October 2001 issue of *Fine Woodworking* magazine. This piece offered a learning experience in a number of classic woodworking features including:

- Dovetail joints in the carcase.
- Bracket base with molded edge.
- Shelf housed in a dado.
- Cornice molding.
- Mortise-and-tenon joinery.
- Frame-and-panel door.
- Shiplapped back panel.

I developed the design in SketchUp and provided the students a multi-page PDF file with instructions and views of the cabinet and its components. I also provided a PDF file containing the full-size templates for carcase dovetails, crown molding, bracket base, and the corner block at the base. All students completed the project successfully.

tails can be "through" (extending the full thickness of both boards, as shown in the exploded view) or "half-blind," with relatively short tails on the top fitting into sockets on the inside face of the side.

The choice of through or half-blind dovetails is a design consideration—whether to have the joinery exposed or hidden. It is done both ways in traditional work. In this cabinet, the cornice covers the joint on the side, but the dovetails will be visible from the top of the finished cabinet. (The base covers the dovetails at the bottom.)

The sides have dadoes to house the shelves. In some cases, the shelves may be held in place with a dovetail instead of a dado or a combination of the two (see Figure 19). The interlocking parts of a dovetail joint help prevent the carcase sides from bowing.

The four pieces of the carcase are rabbeted on the back to house the back panel.

Face Frame This is an optional piece, generally made with mortise-and-tenon construction, as shown in Figure 5. If the cabinet has no face frame, the door extends over the edges of the carcase sides rather than being inset into the face frame. In this cabinet, the paneled door is inset to the face frame. In the shop, the face frame needs to be built and installed on the carcase prior to making the plinth and the cornice molding. These parts are fastened to the face frame with wood screws from inside the cabinet.

Plinth or Bracket Base Typically, the carcase sits in a plinth, sometimes called a bracket base. See Figure 6. The front and sides of the base are shaped, cut to length, and connected with miter joints. This base

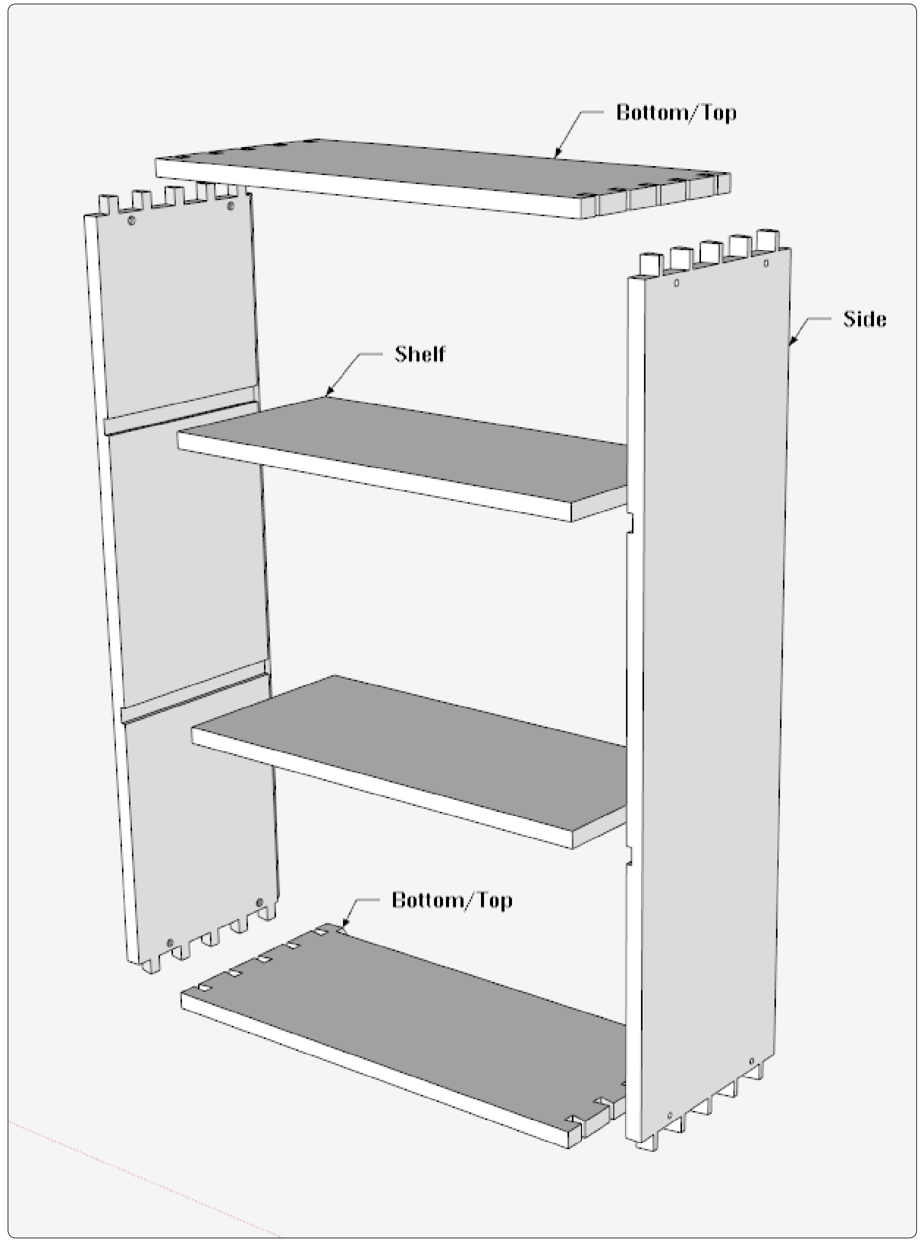


Figure 4. *The cupboard's carcase, exploded in SketchUp.*

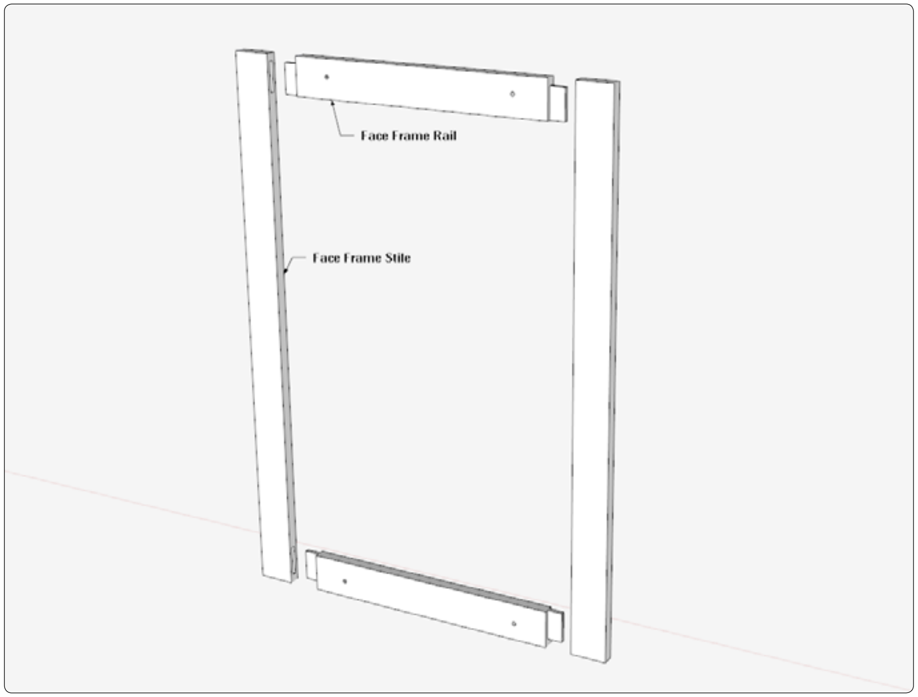


Figure 5. *The exploded face frame. Shank holes are placed in the rails for fastening the plinth and cornice molding with flat-head wood screws.*

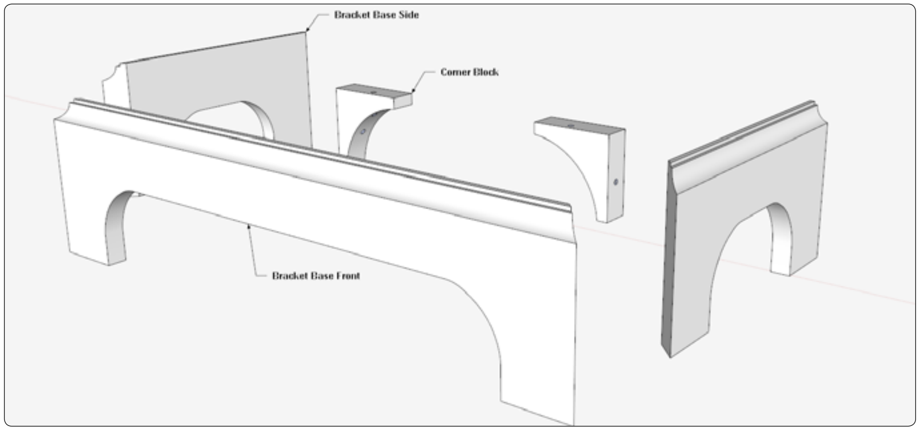


Figure 6. *The exploded plinth or bracket base, with side, front, and corner block components.*

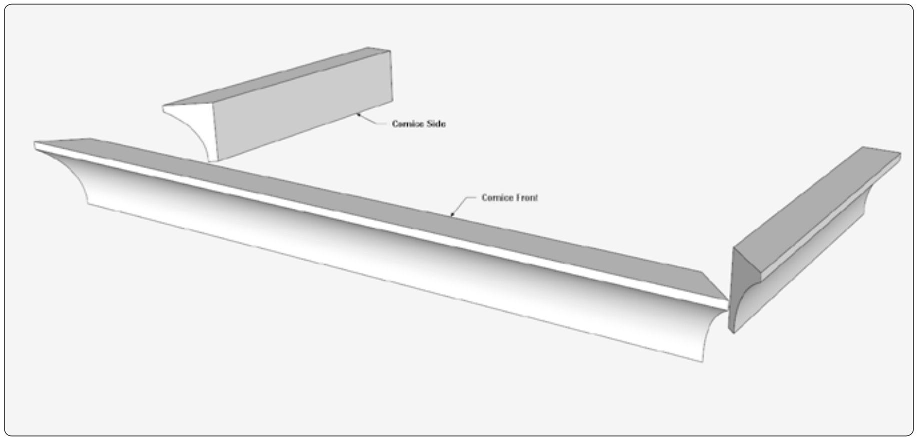


Figure 7. *An exploded view of the cornice molding. It is not always necessary to draw an element like this as separate components.*

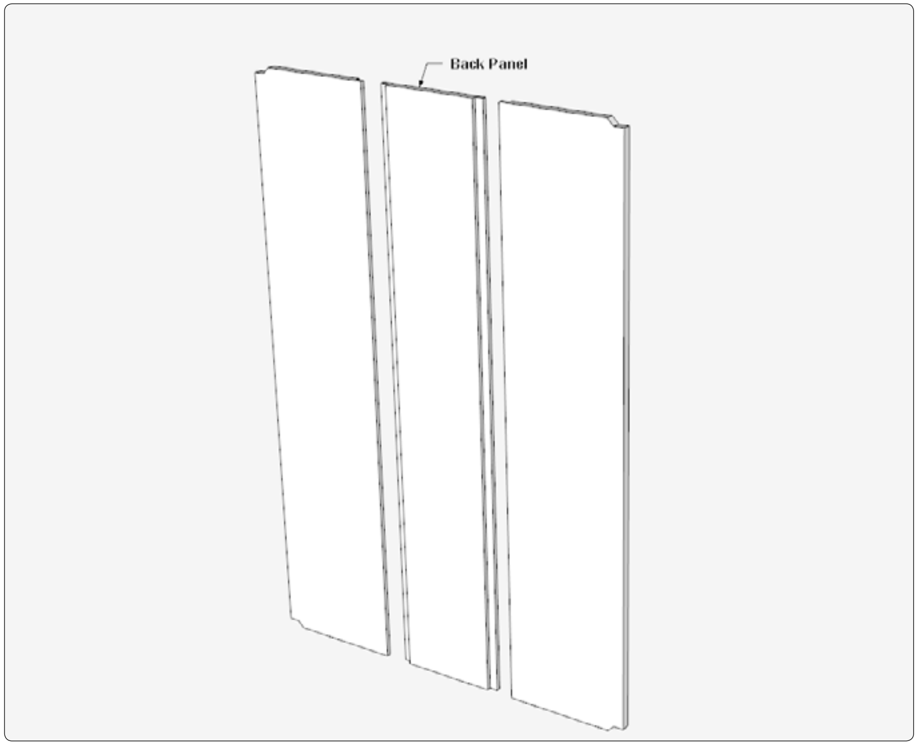


Figure 8. *Shiplapped joints on the back-panel boards allow them to expand and contract with seasonal changes in humidity.*

has corner blocks at the rear instead of a piece extending the full width. A full-width piece makes for a stronger assembly. On blanket chests, the plinth pieces are often connected with dovetails.

On the cabinet shown here, I chose to use wood screws to fasten the base to the case. Nails were used by Dunbar. While historically accurate, this isn't always appropriate, of course. Alternatives include a cleat glued and screwed to the base or a rabbet cut in the top edge of the base.

Cornice Molding Figure 7 shows the exploded cornice molding with miter joints. In SketchUp, I normally do not break up the cornice into the front and side components.. Doing that merely takes time at the computer without saving any time in the shop.

The cornice is fastened to the side and face frame with flat-head wood screws driven from the inside of the case. You can see the shank holes in Figure 4 and Figure 5. The back half of the cornice should be free to move against the vertical grain of the carcase side. In these cases, I apply glue only to the front half of the cornice side components including the miter joint. That allows enough flexibility for cornice movement.

Back Panel Figure 8 shows the exploded back panel. It consists of multiple vertical slats that overlap at the edges with shiplapped joints. The multiple pieces expand with seasonal changes in humidity, but not so much that their movement forces the carcase sides to bow outward.

An alternative is to make the back like a frame-and-panel door, but without the hinges and latch. See Figure 3 in Chapter 3. This type of construction also accommodates seasonal wood movement.

Whatever its design, the back panel typically fits into rabbets on the back edges of the carcase sides, top, and bottom.

Frame-and-Panel Door For cabinets in the traditional style, there is just no alternative to the frame-and-panel door. The panel floats within grooves in the stiles and rails, allowing for seasonal wood movement. The inner edges of the stiles and rails are often profiled with a small bead. The beads are mitered (sometimes coped) at the corners.

The lower rail is always wider than the stiles or the upper rail. See Figure 9. If it were the same as the others, the door would appear out of balance and top-heavy.

Tenons on the rails fit mortises cut all the way through the width of the stiles. This is done to achieve maximum glue area and additional joint strength.

In addition, each mortise-and-tenon joint is strengthened with two pegs driven into holes through the rails and stiles.

This door is inset in the face frame, so flush-mounted H-hinges are used. Conventional butt hinges, mortised into the face frame and stile, would also be appropriate.

Additional Cabinet Varieties

Following the video on the next page, you will find assembled and exploded views of a half-dozen other traditional cabinets: wall cabinets, an entertainment center, a display case, and more. These alternatives can be helpful when you select and start a new cabinet design, helping you identify suitable options for a traditional look, function, and construction.

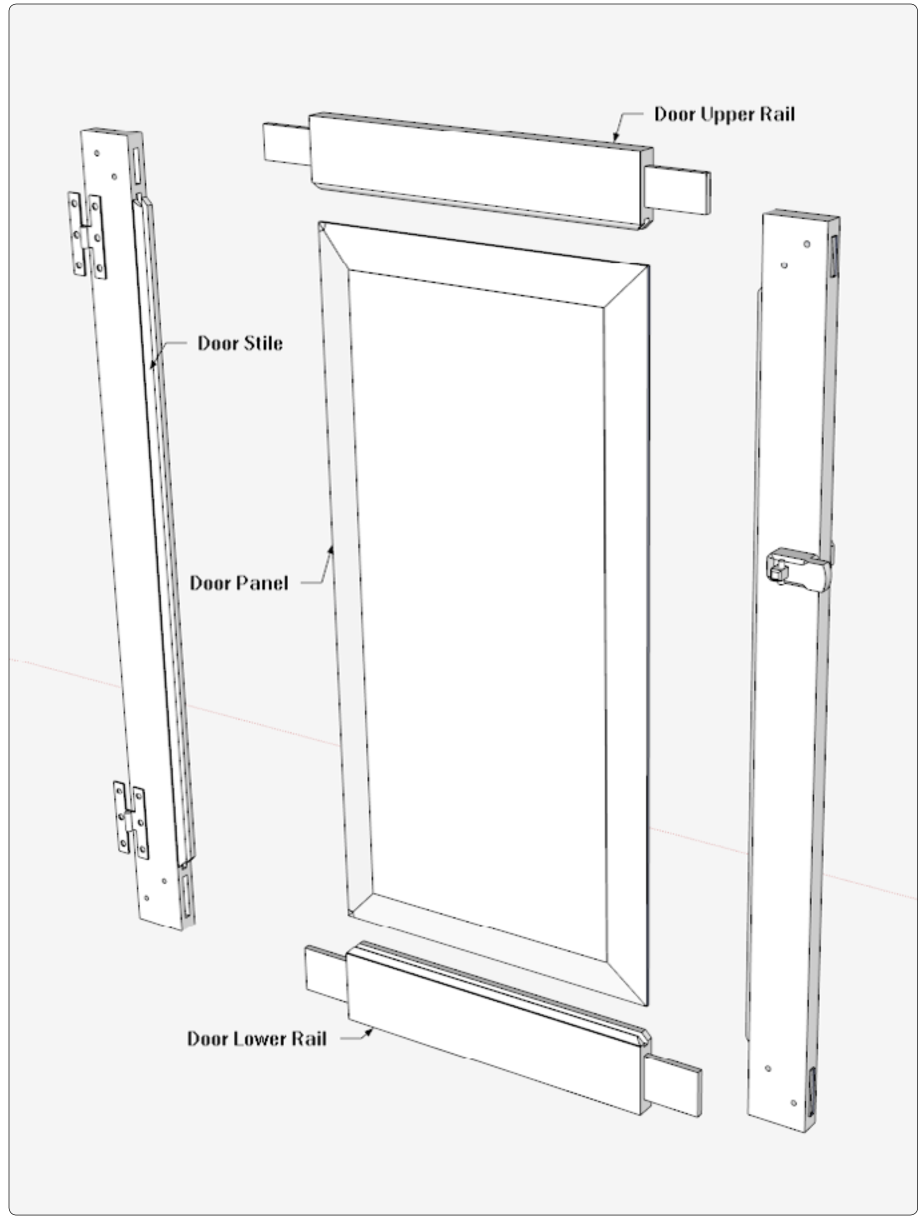
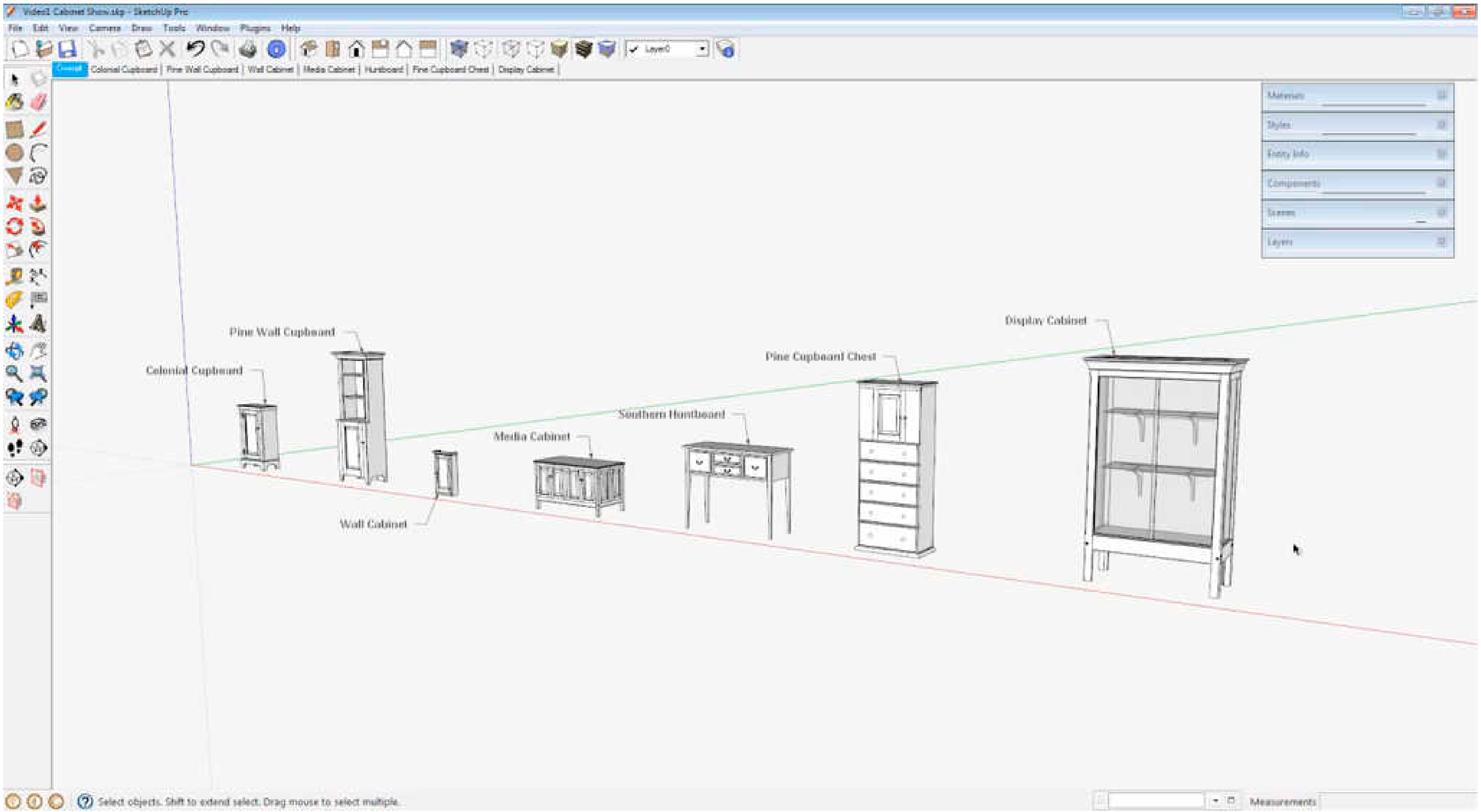


Figure 9. *The traditional paneled door, with pinned tenons on the rails fitting through mortises on the stiles and a beveled panel housed in a groove in the frame.*

Video Tutorial: Cabinets in Close-Up

This brief video gives you a close look at some important construction details on each of the cabinets shown later in the chapter. By zooming in close, pulling individual components away from the assembly, and hiding others, you can clearly see important joinery details like drawer dovetails, a handmade door latch, and the bed bolts used to hold together a massive display cabinet.



A Pine Wall Cupboard

Adapted from *The Pine Furniture of Early New England,* by Russell Hawes Kettell (Dover Publications, 1970).

The book includes a photo of this cabinet but provides no dimensions. When I reproduced the piece, first in SketchUp and then in the shop, I had to estimate sizes and make my own choices for joinery and other details.

The cupboard has no plinth. The sides have cutouts to form the feet at the floor. The sides also have a setback at the division between the open upper shelves and the lower cabinet.

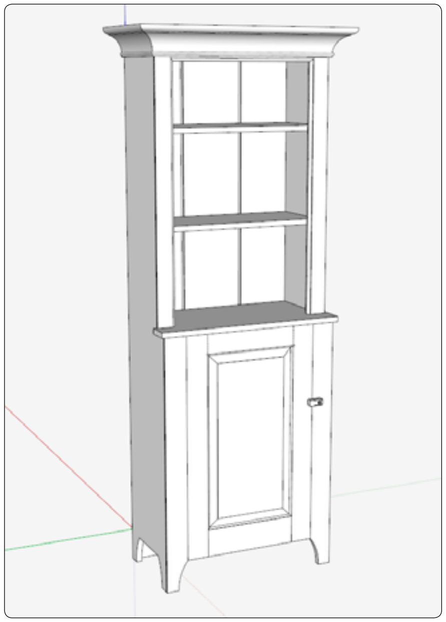


Figure 10. *The assembled view of the pine wall cupboard.*

Figure 11. *Exploded view of the pine wall cupboard. All the joinery is straightforward: Dadoes and rabbets hold the shelves and face frame; mortise-and-tenon joints are used for the frame-and-panel door.*

Wall Cabinet

Adapted from an article by Garrett Hack in the January 2010 issue of *Fine Woodworking* magazine.

The author included two unique features in this small cabinet, which he designed as a toolholder. At the top of the cabinet, just below the cornice molding, he applied a decorative multicolored band. He also connected the top and bottom carcase pieces with sliding dovetails.

One small dovetailed drawer is hidden behind the paneled door. The back is shiplapped.

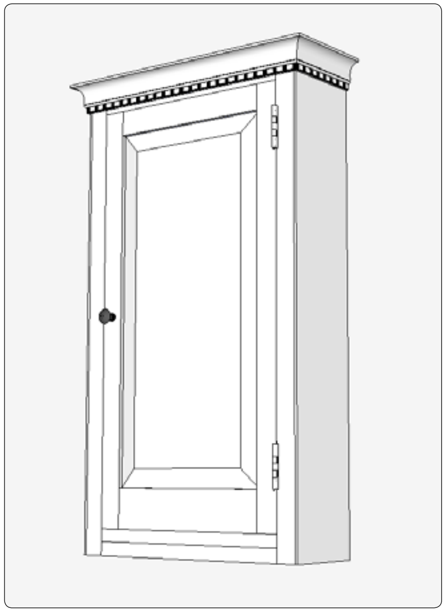


Figure 12. *The assembled view of the wall cabinet.*

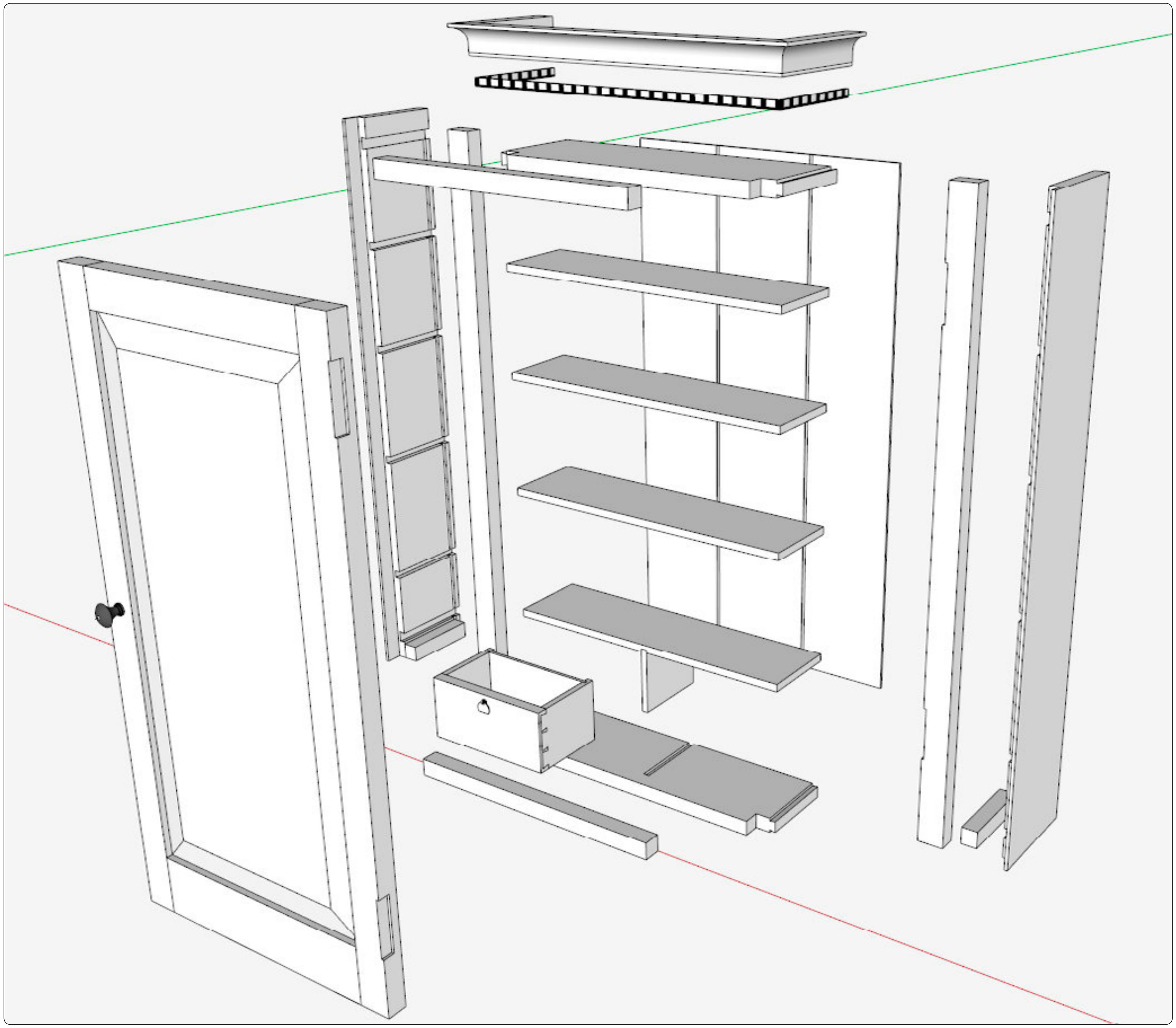


Figure 13. *Exploded view of the wall cabinet, showing the sliding dovetail joints and other case joinery. You can also see the decorative band at the top of the piece.*

Post-and-Panel Media Cabinet

I designed this cabinet to hold modern entertainment electronics and provide a resting place for a large-screen TV.

This design uses a post-and-panel construction, which is quite different from a carcase-type cabinet. Mortise-and-tenon joints connect the four legs and the heavy rails between them.

Traditional raised panels fit between the rails on the sides. The same style of panels is used in the two pairs of doors in the front. I left the back of the piece open to accommodate wiring for the electronics and to allow for ventilation for the components.

The solid wood doors block the signal from standard remote controls. So you need an IR extender to operate the gear in the cabinet.

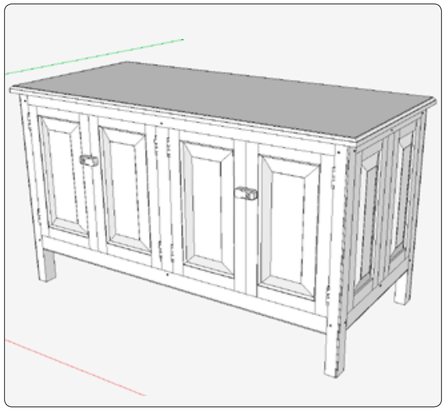


Figure 14. *The assembled view of the post-and-panel entertainment cabinet.*

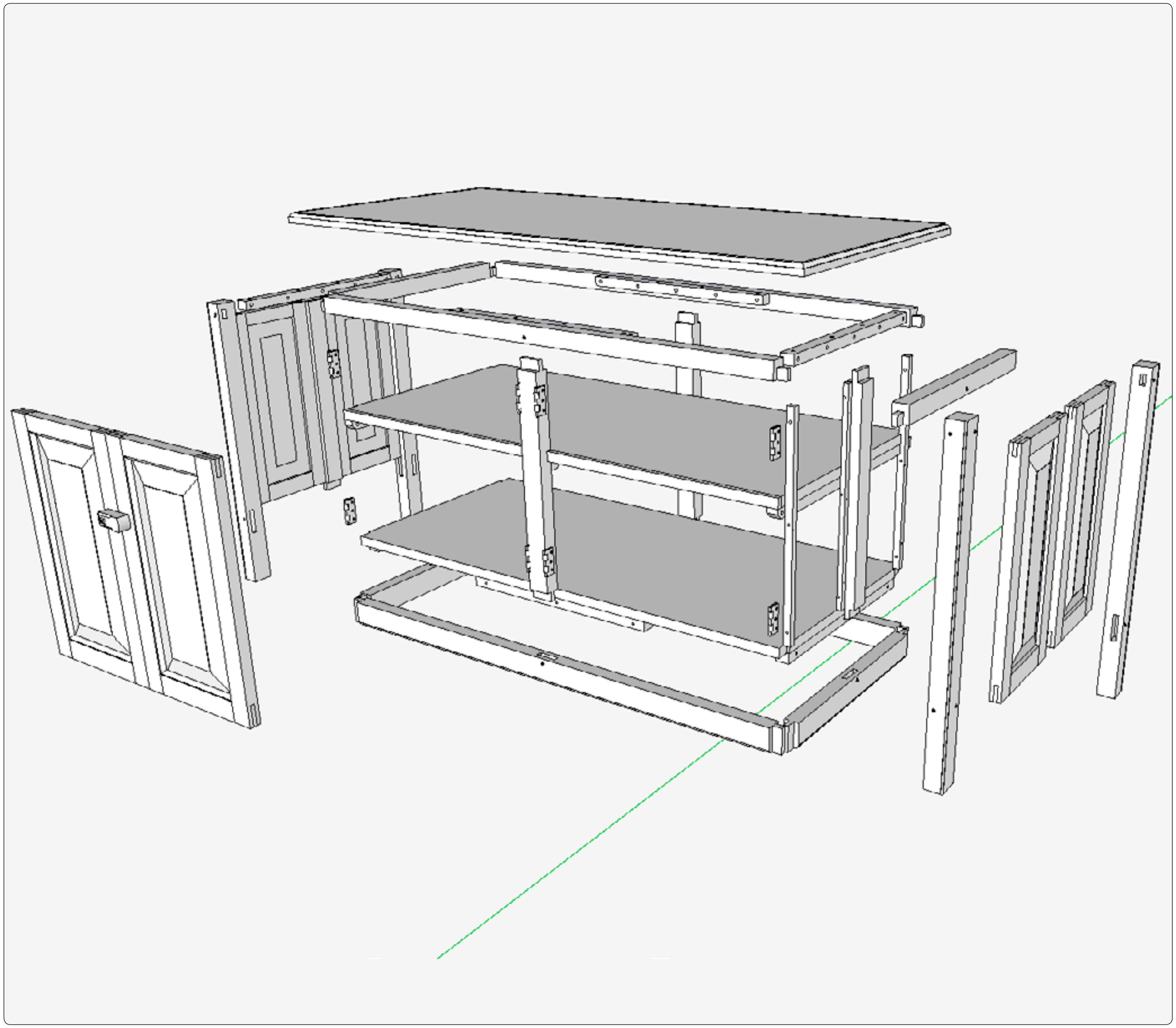


Figure 15. *Exploded view of the post-and-panel entertainment cabinet, showing the beefy rails that connect the legs. A small bead on the outside corner of the legs helps lighten the appearance of the piece.*

Southern Huntboard

Adapted from an article by Carlyle Lynch in the March 1983 issue of *Fine Woodworking* magazine.

Sideboard and huntboard cabinets have unique construction characteristics. Mortise-and-tenon joints connect the legs to the back and sides. A large frame-and-panel assembly forms the bottom of the cabinet.

A front top rail dovetails into the top of the legs and the upper edge of the sides. Partitions and front posts create the drawer openings. Slots cut into the inside face of the back hold the drawer runners and partitions.

Drawer construction is also traditional, with half-blind dovetails at the front and through dovetails at the rear.

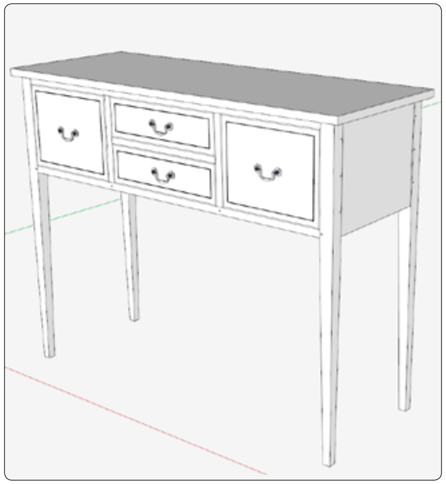


Figure 16. *Assembled view of the southern huntboard.*

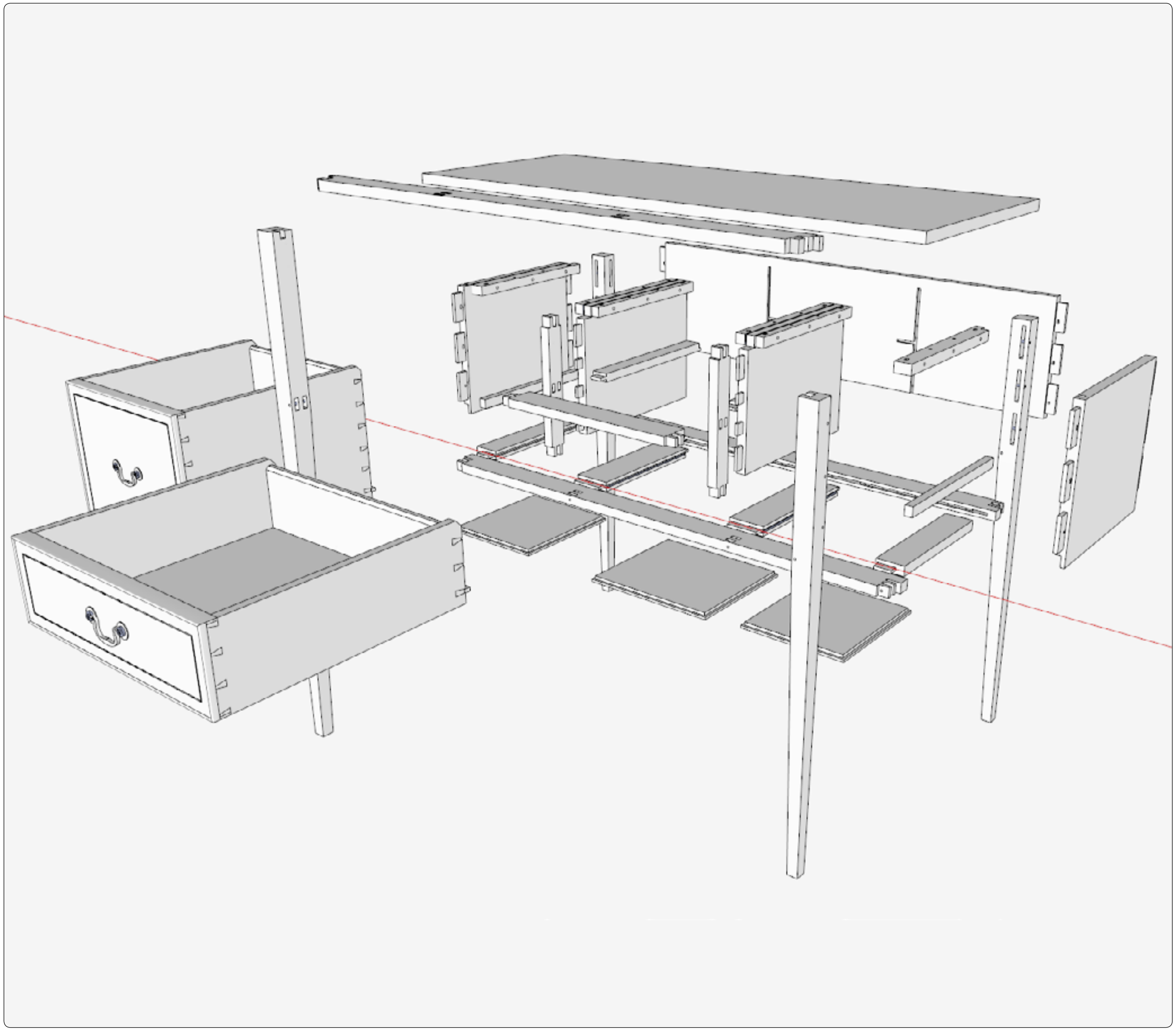


Figure 17. *Exploded view of the southern huntboard. The cabinet is held together with numerous mortise-and-tenon joints, some quite complex, and the drawers are dovetailed. In addition, the drawers are fitted with a cockbead around the front perimeter.*

Pine Cupboard Chest

Adapted from *Shop Drawings of Shaker Furniture and Woodenware, Volume III*, by Ejner Handberg (Berkshire House Publishers, 1977).

This is a tall cabinet with an upper cupboard and a lower set of drawers. The drawing in Handberg's book is not complete or detailed, so I had to make several assumptions about sizes, configuration, and joinery. For example, I've used traditional dovetail construction in the carcase, but I'm not sure what was used in the original piece.

Note the drawer support frames, shown in Figure 19. The frame components are connected with mortise-and-tenon joints. A half-dovetail joins the frame to the carcase sides.

Figure 18. *Assembled view of the pine cupboard chest.*

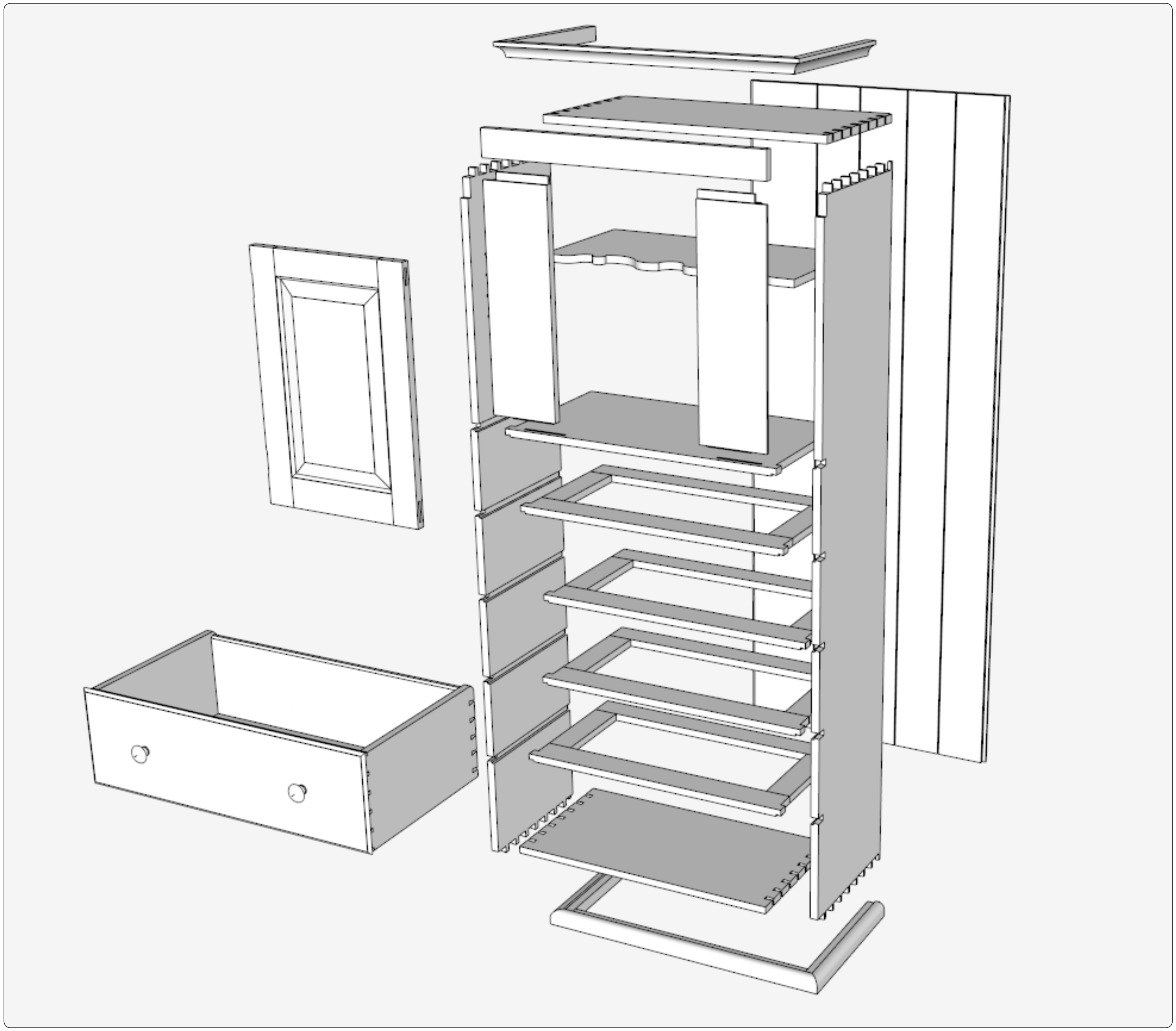


Figure 19. *Exploded SketchUp view of the pine cupboard chest. Note the unusually wide face frame around the door and the scroll shape cut into the front of the shelf in the top part of the cabinet.*

Display Cabinet

This is a tall display cabinet that I designed for the county courthouse. Our local woodworker's club built it and maintains the display of crafts. Strong rails at the top and bottom connect the legs with mortise-and-tenon joints.

Each mortise-and-tenon joint is fastened with a bed bolt (the square recesses in the rails provide access to the nut and washer). The bed bolts allow the cabinet to be dismantled. Antique wardrobes were designed similarly so they could be knocked down and moved up or down narrow staircases.

The legs are grooved to accommodate the thick tempered glass sides. The front has sliding-glass doors and brackets fastened to the back support two glass shelves.

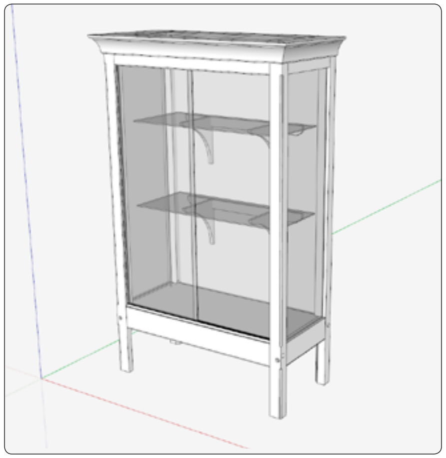


Figure 20. *Assembled view of the display cabinet.*

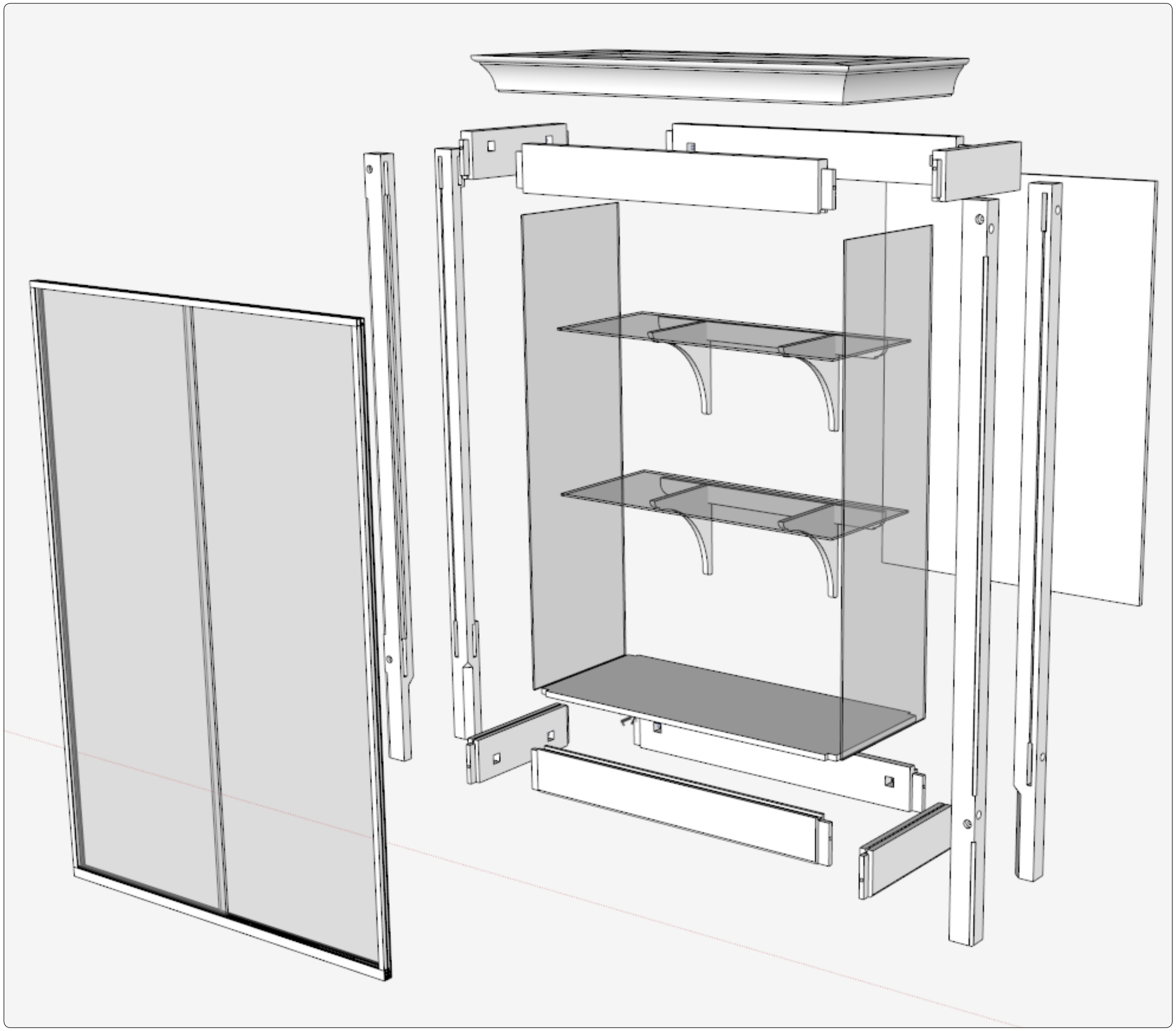


Figure 21. *Exploded view of the display cabinet. It is held together with bed bolts, so it can easily be knocked down, moved, and reassembled. Long before IKEA arrived, wardrobes and other large case pieces were designed to be knocked down and put together this way.*

A Wall-Mounted Cabinet

Our house always seems to lack storage space. Whether it is in the bedrooms, garage, family room, kitchen, home office, or shop, we often just pile stuff wherever we can. There are never enough bookshelves and cabinets, and never any floor space for new furniture. As a result, open walls become opportune spaces for helping solve this problem. Not only do wall-mounted cabinets free up floor space, but they also keep things at a convenient height for grownups while restricting access for toddlers.

This chapter features a wall cabinet by Chris Gochnour, described in the Winter 2000/2001 issue of *Fine Woodworking* magazine. Chris designed this beautiful piece to hold his collection of *Fine Woodworking* magazines, but the cabinet's structure, size, and appearance certainly make it more generally useful.

This is an excellent example of high-quality cabinet design and construction, one to emulate in your own designs. Gochnour's cabinet incorporates classic joinery: mortises and tenons, through dovetails, and wedged mortises and tenons. The doors and back are frame-and-panel components in solid wood. A French cleat provides an especially strong connection to the wall.

Filling in gaps

The magazine article provides considerable detail and gives several dimensions. It also includes an exploded isometric view of the cabinet, showing the joinery and the

Figure 1. *The finished SketchUp model of the wall-mounted cabinet and Gochnour's original.*

arrangement of cabinet parts. Compared with other published plans I have used, this one is surprisingly accurate. Still, the article doesn't deliver all the information you need. If you were to go to the shop with only the magazine, you would find yourself trying to calculate missing dimensions or even sketching some details.

The article leaves many specifics about the joinery for you to figure out. For example, a few mortises are labeled with dimensions, but it is not clear where to cut them. The French cleats are an integral part of the carcase structure, yet the article does not give their size or where to locate mortises for the cleat tenons. Perhaps most significantly, the article gives no sizes for the dovetails and tenons on the upper and lower ends of the side pieces.

Rather than deal with those issues in the shop, it is much better to sort them out first in SketchUp. This will not guarantee a perfect job, but it will significantly cut down on reworking and improvised changes or corrections to the plan, thereby improving your efficiency in the shop.

I'll show later in this book how to reuse and resize components from previous SketchUp models to accommodate custom changes. The more modeling you do in SketchUp, the more powerful it becomes in providing parts, shapes, moldings, hardware, and joints to be used later for new cabinet designs.

This chapter will be divided into eight subsections of SketchUp modeling:

- Constructing the cabinet carcase.
- Adding dovetail joints in the top.
- Making the wedged mortise-and-tenon joints.
- Creating the back panel.
- Adding the shelf and French cleat.
- Extruding the cove molding.
- Building the doors.
- Making the handle and hinges.

The sequence of modeling is very much aligned with that used in the shop. This is very typical of the way I approach SketchUp modeling of furniture—that is, it follows the procedure I would also use in actual shop construction.

Because this is the first modeling exercise in the book, I will show each step in SketchUp, what tool to use, and when to click the mouse. I will assume you are beginning with SketchUp and would benefit from seeing each step. As we move forward through the book, I will skip steps and procedures as you advance in capability and skill.

Each of these subsections will be introduced by one or more dimensioned detailed drawings. These are useful references when doing the SketchUp modeling.

Some sections also begin with a short video. I recommend reviewing the video first. It will move through the SketchUp process for that particular part of the construction. After viewing the video, you will be better prepared to go through the page-by-page and step-by-step procedures.

Figures 1 through 4 show information on the overall assembly of the wall cabinet. You may want to have copies of these handy beside your computer.

I've found that an iPad or similar tablet is helpful in displaying the eBook next to the computer running SketchUp. Otherwise, you can print the chapters to have a ready reference on your desktop.

Quantity	Description	Length(L)	Width(W)	Thickness(T)
Carcase				
2	Side	28 3/8"	10 7/8"	3/4"
1	Bottom	23 3/8"	11 7/8"	3/4"
1	Top	23"	11 3/4"	3/4"
1	Shelf	21 7/8"	9 1/2"	3/4"
16	Tenon Wedge	3/4"	1/4"	1/8"
1	Upper Cleat	22 1/2"	3"	3/4"
1	Lower Cleat	21 1/2"	3"	3/4"
1	Cove Molding - Front	25 3/4"	13 1/8"	1 1/2"
2	Cove Molding - Side	13 1/8"	2 1/8"	1 1/2"
Back Panel				
1	Back Center Rail	17 7/8"	2 3/4"	1/2"
2	Back Panel Insert	17"	10 1/8"	1/2"
2	Back Rail	17 7/8"	2 3/4"	1/2"
2	Back Stile	27 1/4"	2 3/4"	1/2"
Doors				
2	Door Stile Inside	26 3/4"	1 3/4"	3/4"
2	Door Stile Outside	26 3/4"	1 3/4"	3/4"
2	Lower Door Panel	15 1/4"	8 3/8"	5/16"
2	Upper Door Panel	6 3/4"	8 3/8"	5/16"
2	Middle Door Rail	10"	1 1/2"	3/4"
2	Lower Door Rail	10"	2 1/4"	3/4"
2	Upper Door Rail	10"	1 3/4"	3/4"
2	Handle Dowel	3 1/8"	5/16"	5/16"
4	Handle Post	1 1/8"	1/2"	1/4"
4	Leaf Hinge	2"	1/2"	

Figure 2. *Cutlist for the wall-mounted cabinet.*

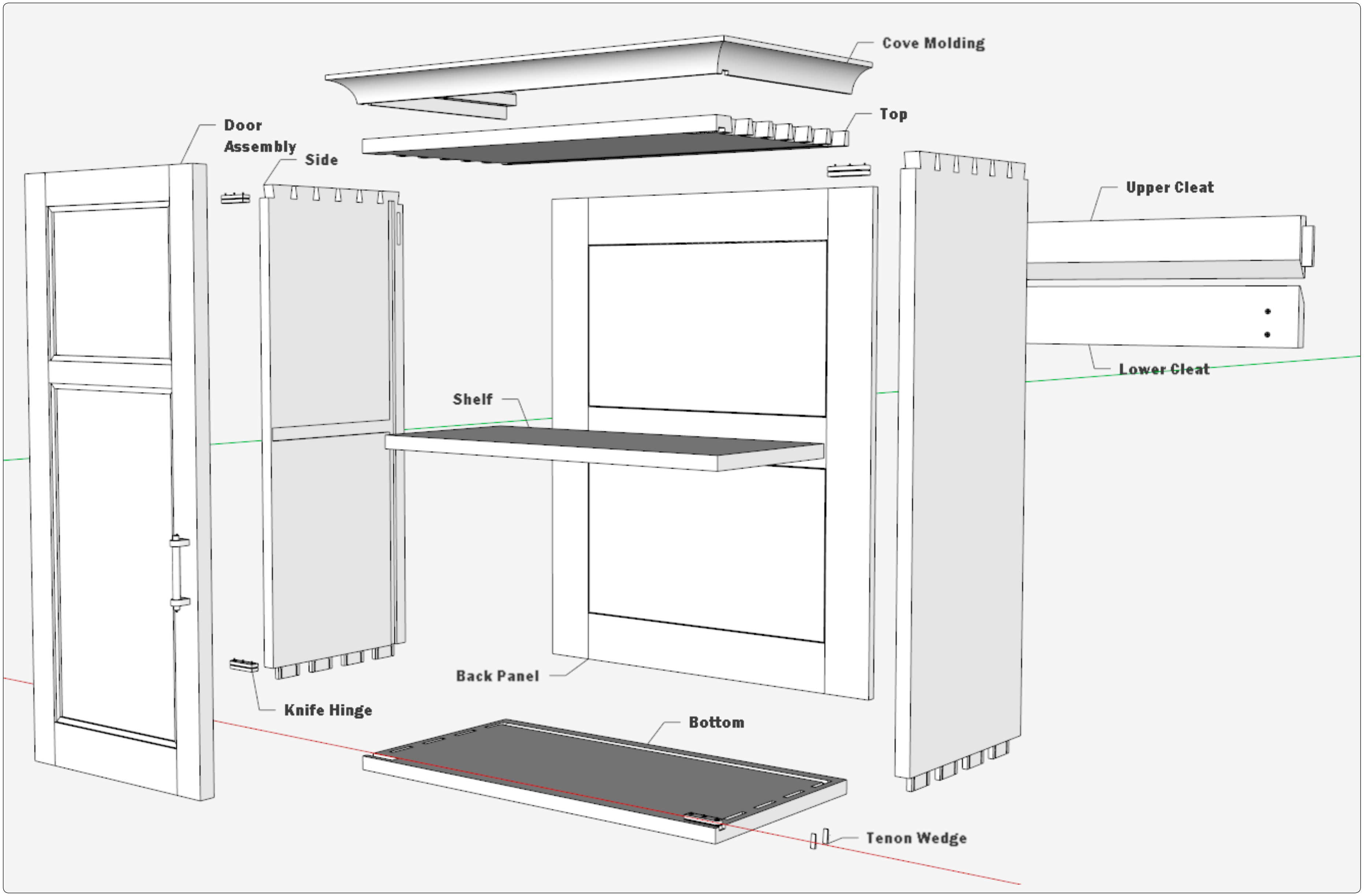


Figure 3. *An exploded view of the cabinet parts.*

Cabinet Design Considerations

When you design a wall cabinet, there are a few important considerations to keep in mind:

A wall cabinet needs a reliable and strong connection to the wall, so the mounting solution needs to be incorporated into the cabinet design.

Excessive length can cause the shelves to bow or deflect under load. For ¾-in.-thick shelving, I like to keep the length below 30 in.

Spacing between shelves should accommodate the tallest book, magazine, or other item you expect to put in the cabinet.

The depth of the cabinet should be sufficient for the largest book or whatever is planned.

Open shelving without doors is an alternative, but this produces a bookshelf, not a cabinet.

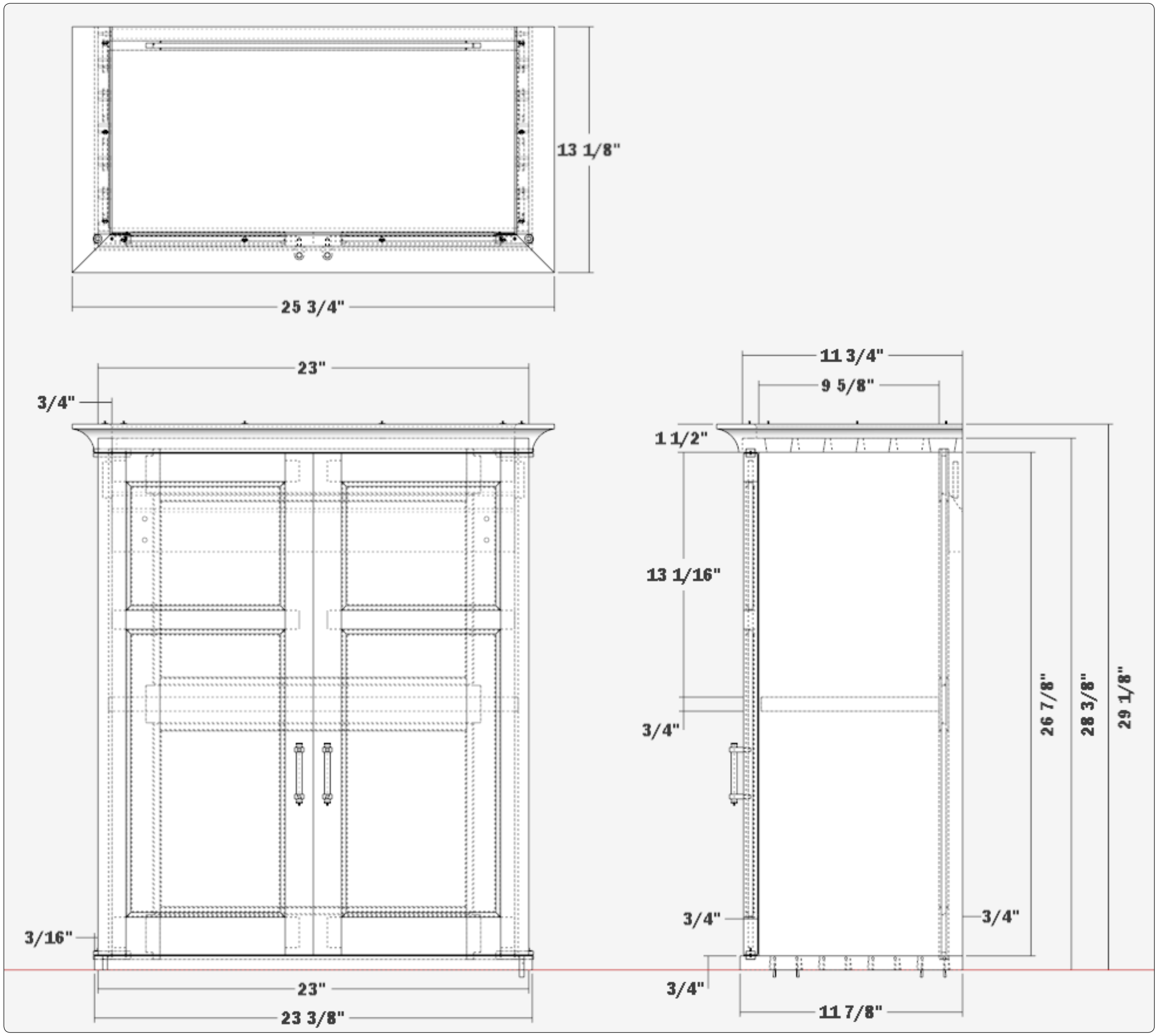


Figure 4. *Front, side, and top orthographic dimensioned views.*

Section 1. Constructing the Carcase

The carcase is the natural starting point for the wall cabinet. It consists of four pieces: the sides, top, and bottom or base. In SketchUp parlance, though, the carcase consists of three components, or discrete elements: top, bottom, and side. Because the two side pieces are identical, in SketchUp you draw one side component and copy it.

At this stage you are only sizing the boards that form the carcase. You will add the joinery in the next section.

There are two differences between constructing a model in SketchUp and constructing the actual piece in the shop. In SketchUp, you can show pieces overlapping at their ends. This will make it easier to draw precise joints. And you draw components in position instead of creating them in one place and moving them into the model. This not only makes the modeling go faster, but it also helps ensure that the components in your model are properly sized.

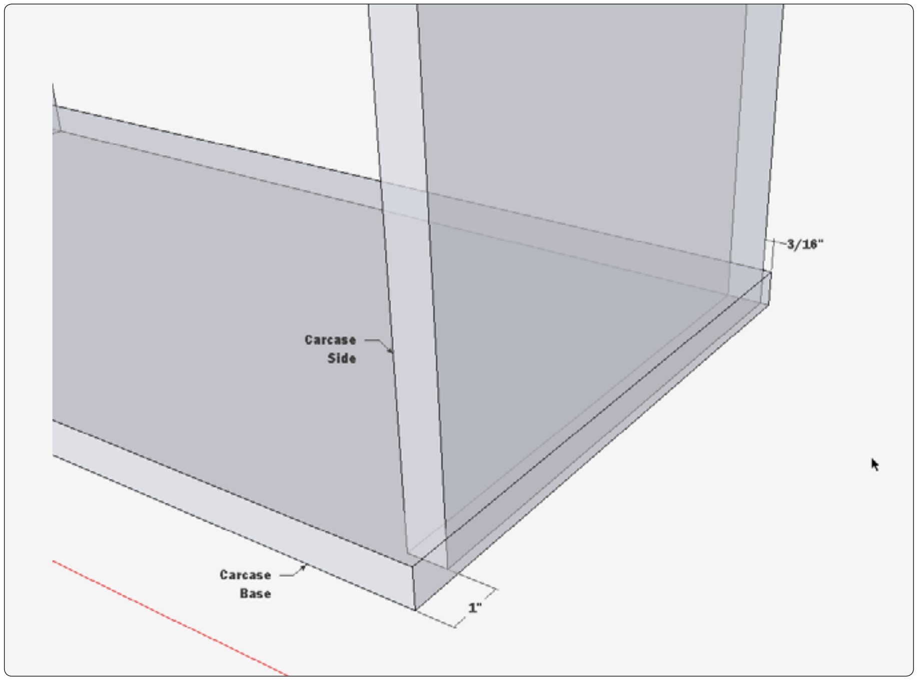


Figure 5. *An X-Ray view of the carcase parts overlapping at the lower end of the cabinet.*

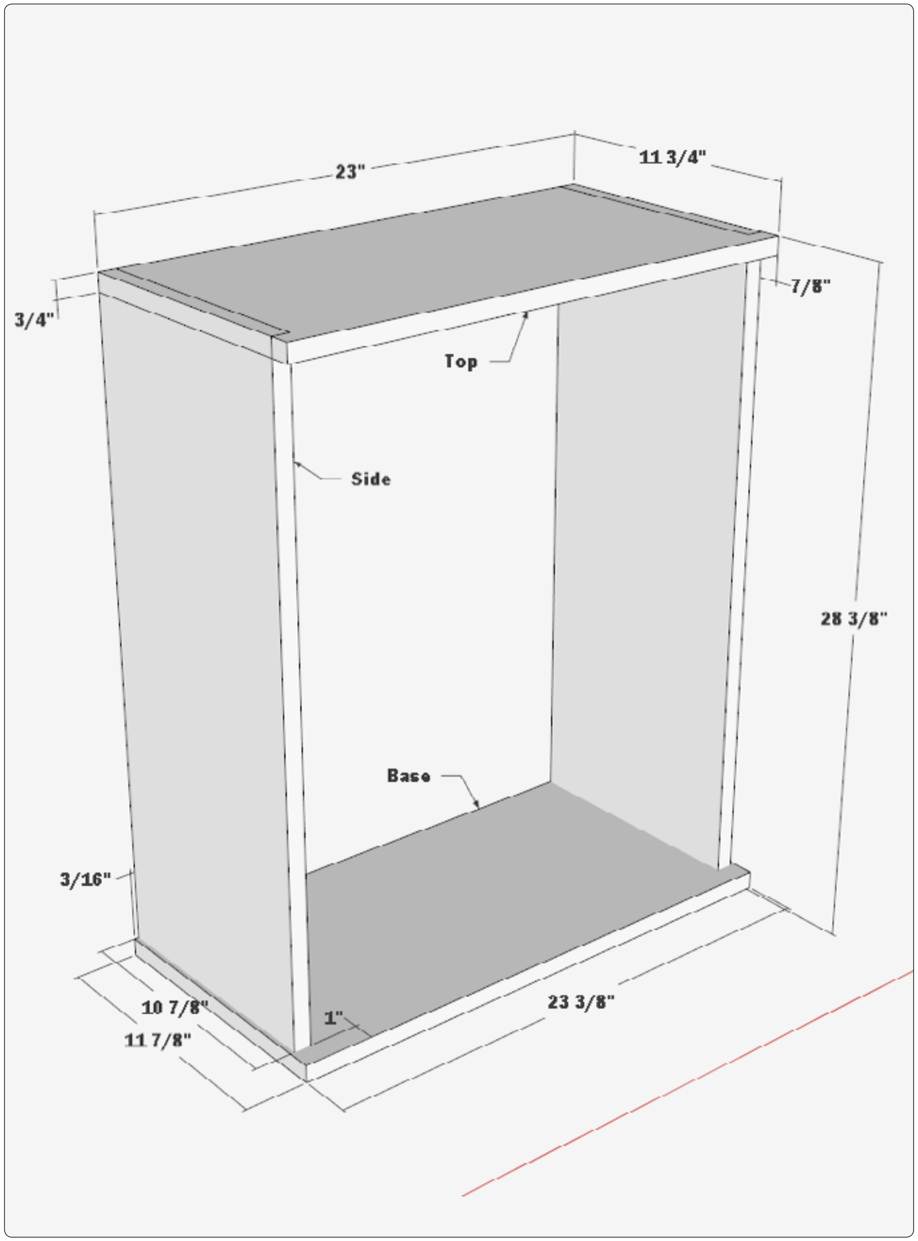
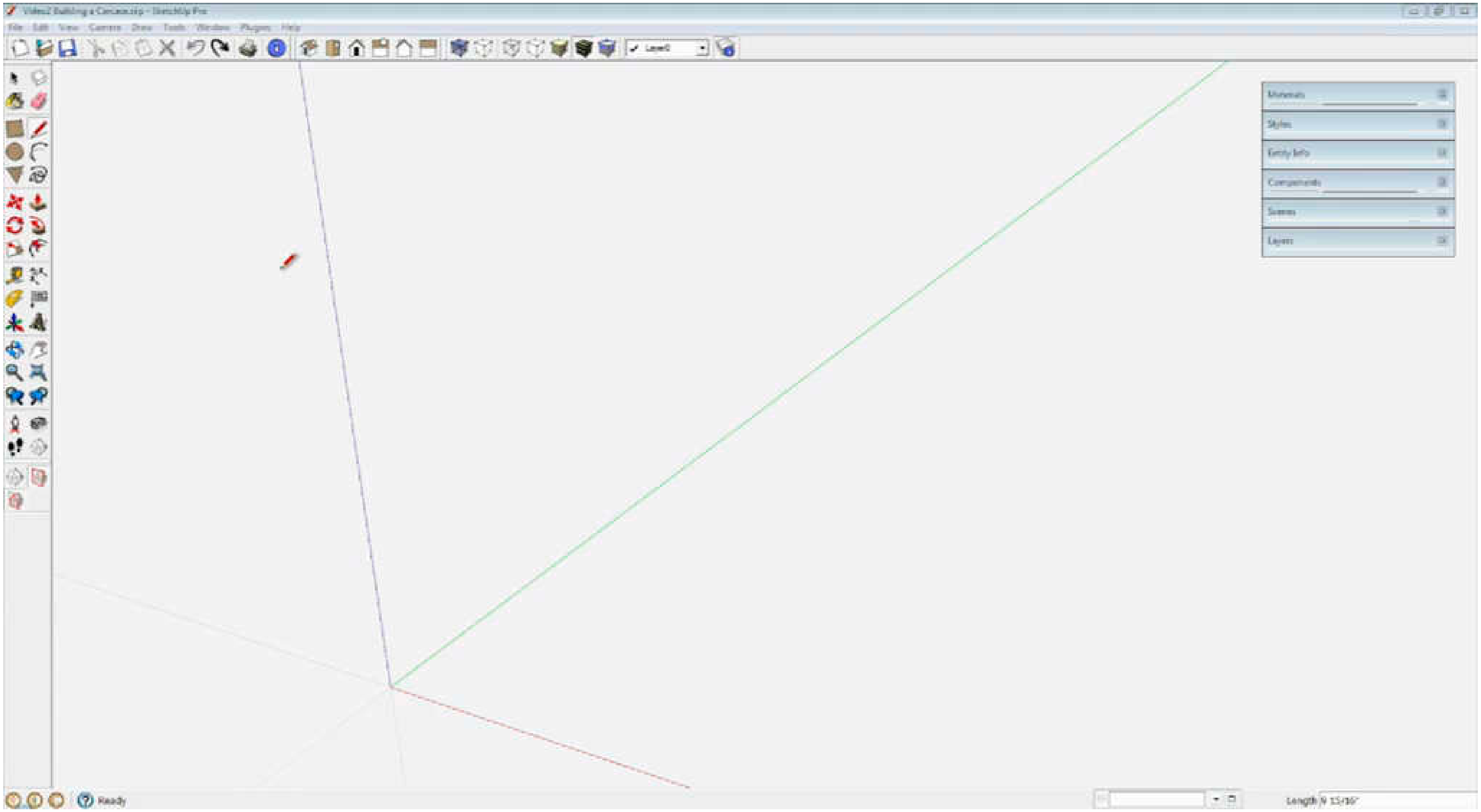


Figure 6. *An assembled view of the carcase overlapped at the corners without joinery.*

Video Tutorial: Building the Carcase

This video shows the steps you follow to create each of the three components in the carcase. It also shows how to copy the side component, flip it so that it is oriented properly in the model, and place it in exactly the right position.



Constructing the Cabinet Carcase

Starting a SketchUp model is very much like beginning the actual construction in the shop. In this case, the starting point is the cabinet side.

Step 1 As shown in Figure 7, arrange the SketchUp window so that the origin and the three axes are visible. Select the Line Tool and click the mouse near the origin. Begin moving the mouse to generate a line moving toward the top of the screen. The line should be blue and you should see a box saying "on blue axis," showing that you've locked on the blue (vertical) axis. Type 28⅜ for the height of the side and press Enter. Begin moving the mouse in the green direction. Type 10⅞ (the width of the side) and press Enter again.

Move the Line Tool down the blue axis again and watch for the inference to the opposite corner. You should see one black dot where you began drawing the line and another at the end of the line you are drawing. If you don't get the inference, coax it by touching the starting corner with the Line Tool cursor, then move back to line up with the blue axis and click the mouse. Close the rectangle by drawing a line in the green direction back to the starting point.

Step 2 If you have drawn the rectangle correctly, it will fill with a color, creating a face, as shown in Figure 8. Double-click on the face to select the entire rectangle. Right-click on the selection and choose Make Component from the pop-up menu.

A Create Component dialog box will appear, as shown in Figure 9. Type Case Side to name the component. Press the Enter key or click the Create button.

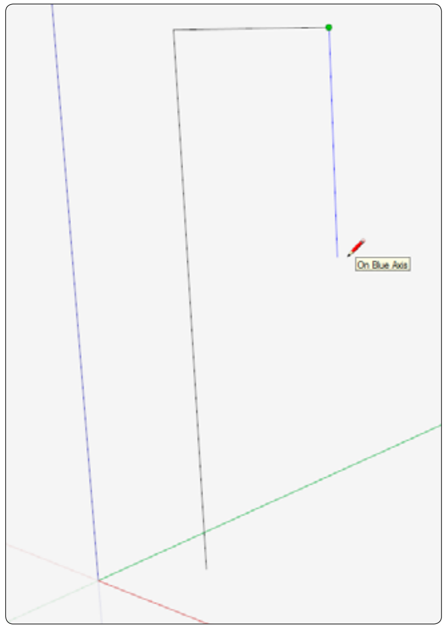


Figure 7. *Use the Line Tool to draw a rectangle for the cabinet side.*

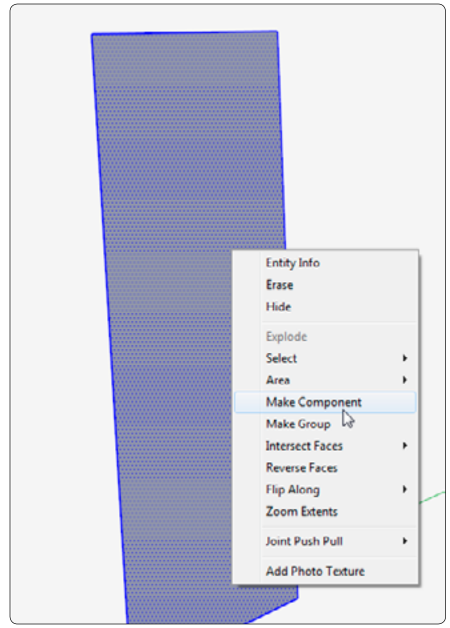


Figure 8. *When the rectangle face appears, make the shape a component.*

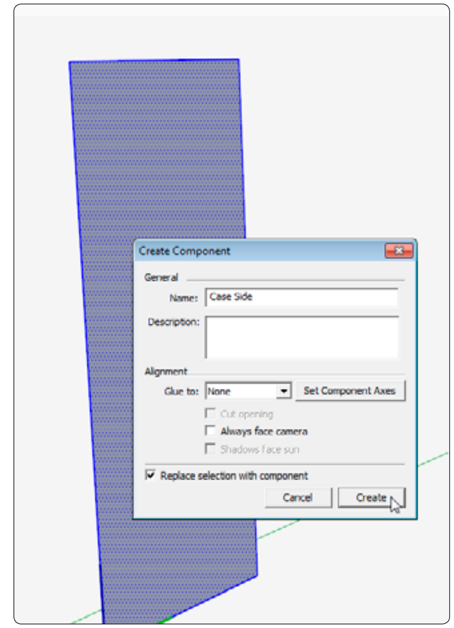


Figure 9. *Name the component Case Side and press Enter or click the Create button.*

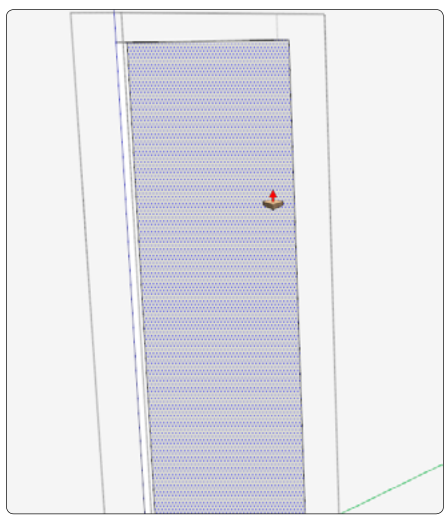


Figure 10. *Use the Push/Pull Tool to make the case side ¾ in. thick.*

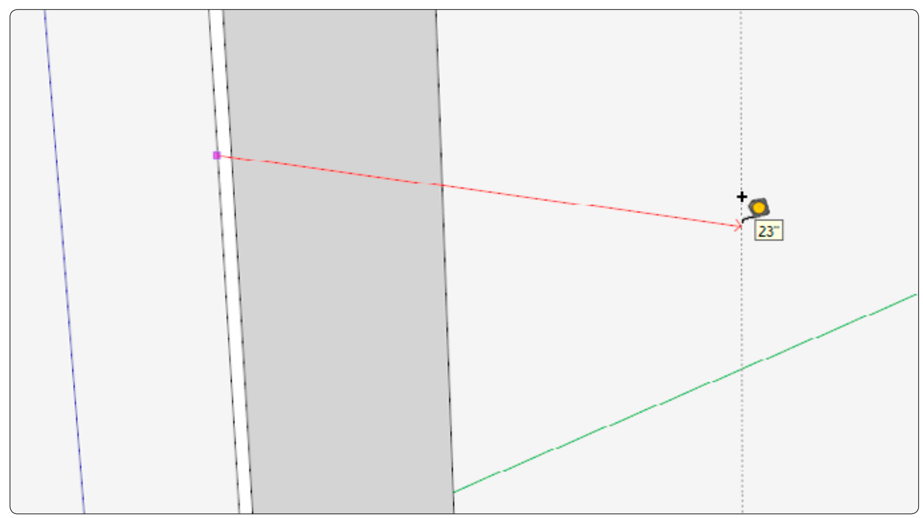


Figure 11. *Use the Tape Measure Tool to place a guideline 23 in. from the outer edge of the case side component and parallel to it, to help you position the second case side.*

Step 3 Double-click on the case side component; you will see a dotted box surrounding it, telling you that the component is open for editing. Select the Push/Pull Tool, click on the face, and begin moving the mouse to the right to give the component thickness. Type ¾ and press Enter. See Figure 10.

Step 4 Now you will begin creating a mirror image of the case side component and placing it in position.

Select the Tape Measure Tool and click on the outer edge of the case side component. Move the tool from left to right, following the red axis, as shown in Figure 11. Type 23 and press Enter. This places a temporary guideline to help you position the right side component.

Select the Move/Copy Tool, click on the inside corner of the case side component, and tap the Ctrl Key (Option on the Mac). This generates a copy of the component. Move the copy to the right along the red axis. When the cursor reaches the guideline, click the mouse to place the copy precisely at that point. See Figure 12.

The right-side component must be "flipped," or mirrored. Right-click the mouse on the copy you just positioned. Choose Flip Along from the pop-up menu. Another pop-up menu will appear; click on Component's Red. See Figure 13. Although these two steps mirror the right-side component appropriately, you will not notice any movement or change in it now, because it has no joinery or other features that would make the mirroring apparent.

Step 5 SketchUp models are made component by component, much like the actual

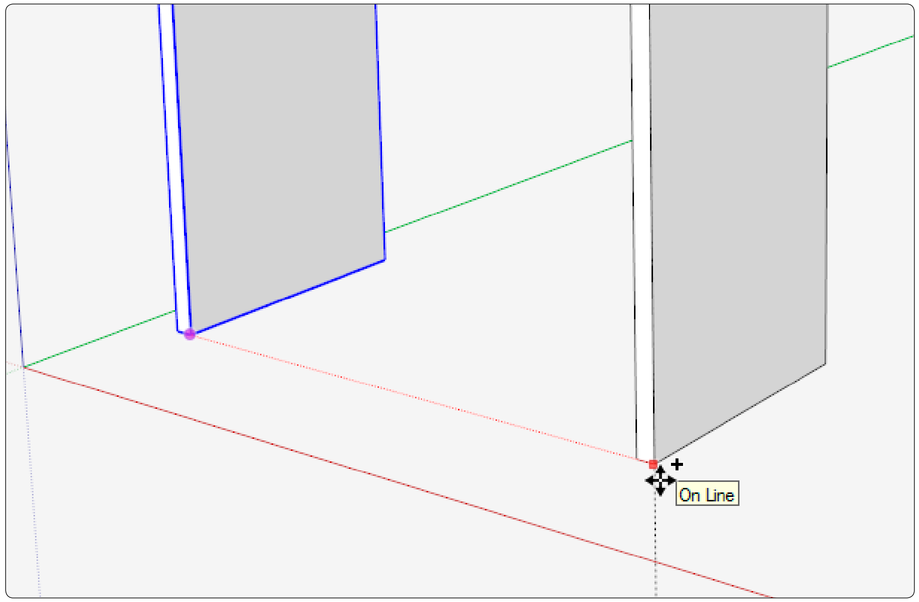


Figure 12. *Make a copy of the case side component and move it along the red axis until the corner just touches the guideline.*

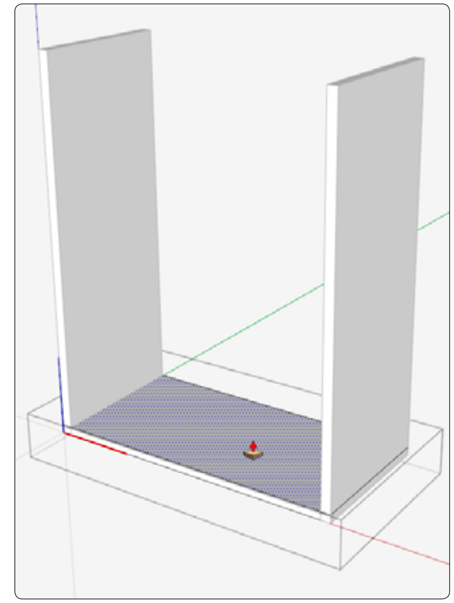


Figure 14. *Create the bottom component and give it a thickness of ¾ in.*

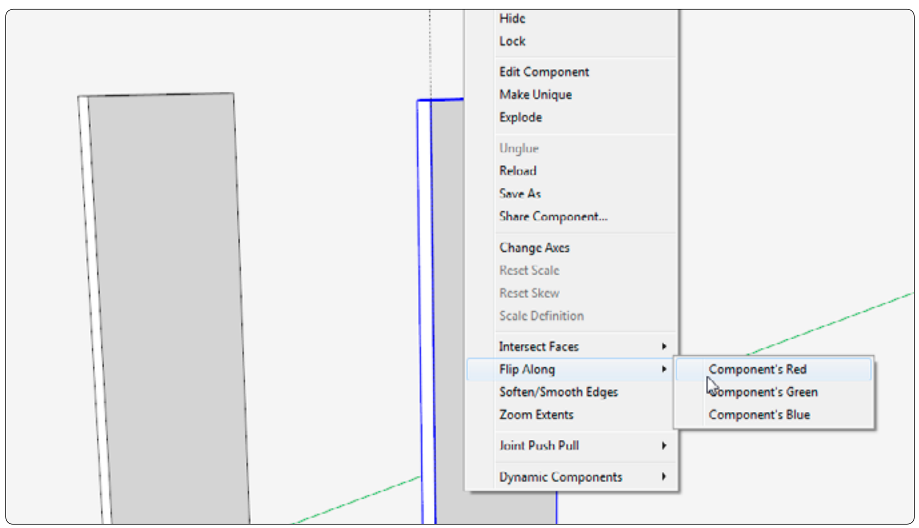


Figure 13. *Execute a Flip Along Component's Red command to mirror the right side component so that it is properly oriented in the model.*

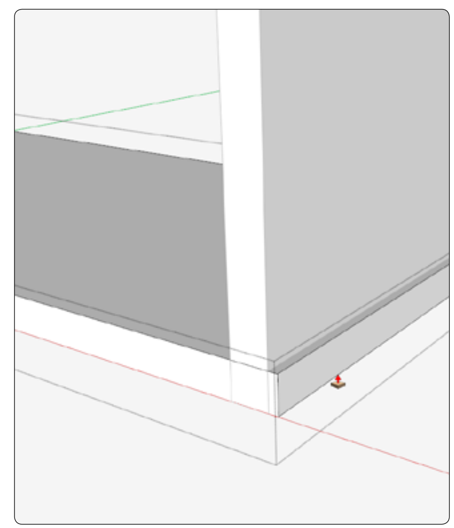


Figure 15. *Extend the ends of the bottom 3⁄16 in. beyond the outside face of the sides.*

construction work in the shop. Each new component should be created in the context of the assembled model. That is, you make new stuff to fit existing parts. This eliminates mistakes in measurements and reduces rework.

For the next component, the bottom, you will create it in position, touching the case-side components.

Use the Orbit Tool to rotate the model so you can see the bottom of the case-side components. Use the Line Tool to draw a boundary around the sides, corner to corner, creating a rectangular shape on the bottom edges of the sides. Right-click on that rectangle, select Make Component, and name it Bottom.

Open the bottom component for editing, then use the Push/Pull Tool to give it a thickness of ¾ in., as shown in Figure 14. Note that the ends of the bottom component should overlap the case-side components.

Step 6 As you can see from Figure 6, the bottom component extends past the side components by 3/16 in. Open the bottom component for editing and use the Push/Pull Tool to lengthen each end of the bottom by 3/16 in. Begin extending the component, type 3/16, and press Enter.

In addition, the front edge of the bottom component extends beyond the front edge of the sides by 1 in. Again, use the Push/Pull Tool to pull the edge out by that amount, as shown in Figure 16. This completes the creation of the cabinet's bottom component.

Step 7 The top component is created in the same way. Orbit so you can see the top of the side components. Use the Line Tool to draw a boundary around the perimeter at the top of the cabinet, as shown in Figure 17. When the rectangular face appears, double-click on it, then right click. Select Make Component and name it Top.

Open the top component for editing. Use the Push/Pull Tool to give it a thickness of ¾ in. The top component should overlap the case-side components at the ends. See Figure 18.

The front edge of the top component extends ⅞ in. beyond the case-side components. Use the Push/Pull Tool to lengthen the front of the top, using the same procedures you followed to extend the edges of the bottom component. See Figure 19.

This completes the initial construction of the four main components that make up the cabinet's carcase. You should have an initial assembly of carcase components as shown and dimensioned in Figure 6.

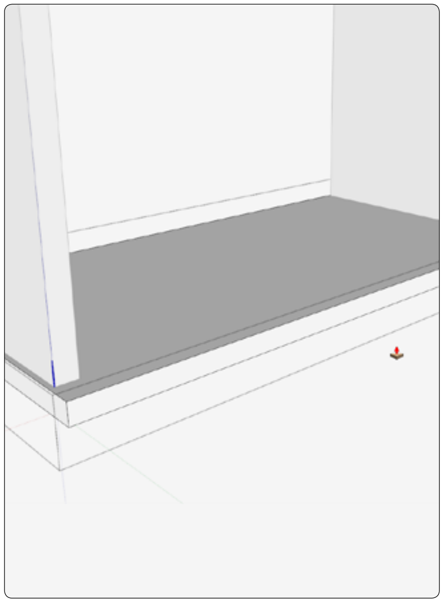


Figure 16. *Pull out the front of the bottom component 1 in. beyond the sides.*

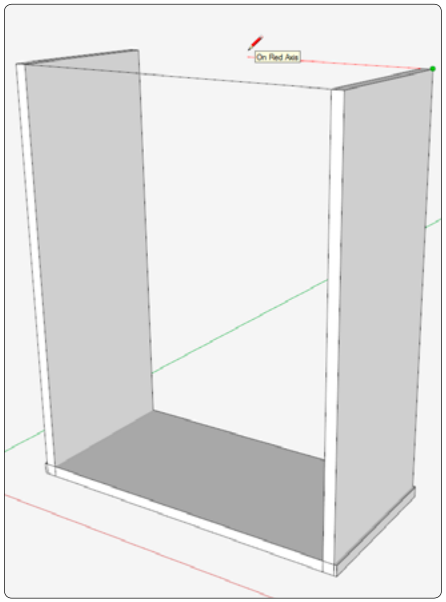


Figure 17. *Draw around the perimeter at the cabinet top to create the top component.*

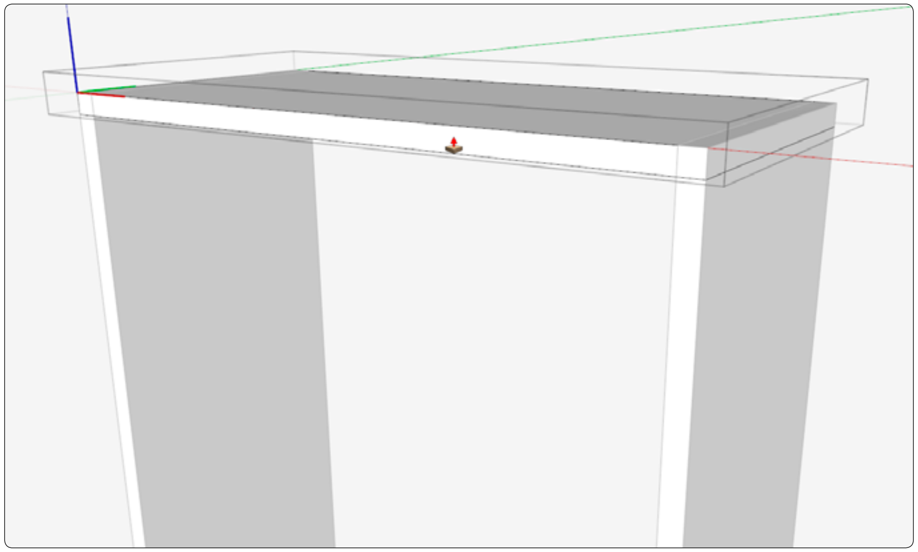


Figure 18. *Give the top component a thickness of ¾ in.*

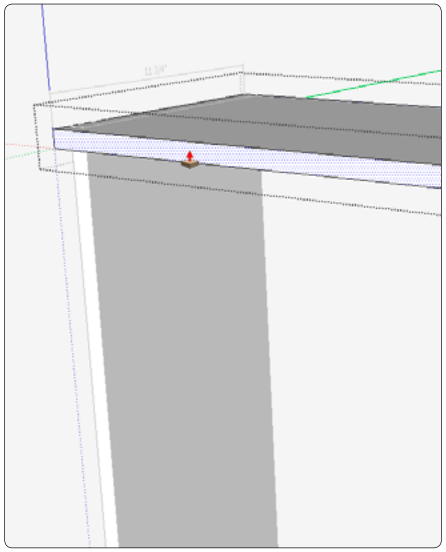


Figure 19. *Pull out the front edge ⅞ in.*

Section 2. Adding Dovetail Joints at the Top

In this section, we'll begin the joinery by creating the dovetails at the top corners of the carcase. In the shop, you would have to saw and chisel both sides and both ends of the top to complete the joinery. In this instance, SketchUp is quicker: You need to create only one set of dovetails. You then copy that set and paste it to the other side, then erase the waste.

This section also introduces you to a handy feature of SketchUp: the ability to divide a line into any number of equal segments. This helps with spacing and alignment of the dovetail pins and tails; it's analogous to using dividers to determine the spacing of the joint segments. In this case we'll start with the tails and use them to make the pins. That's how I usually cut dovetails in the shop.

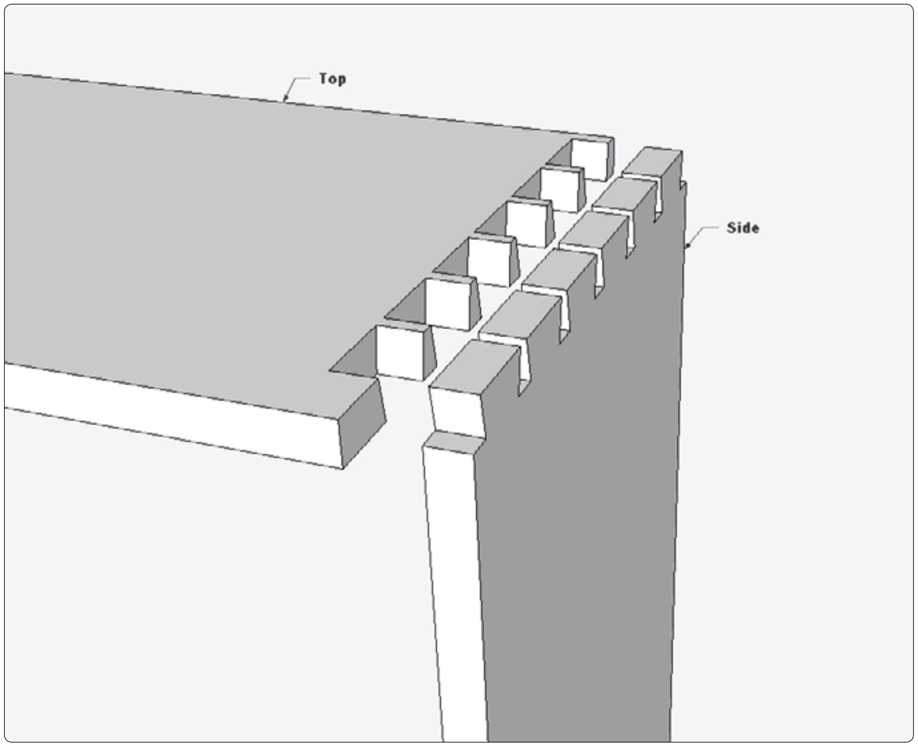


Figure 20. *The dovetails ready for assembly.*

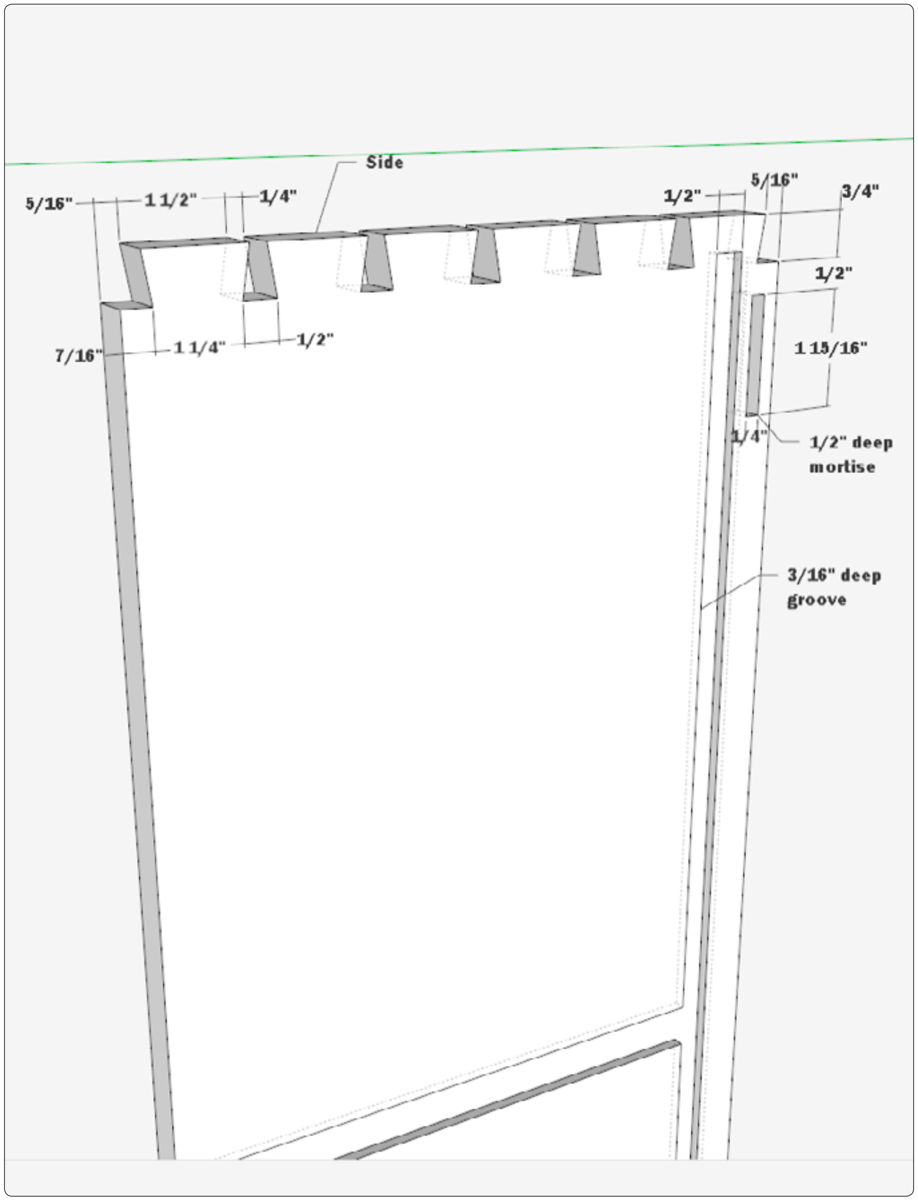
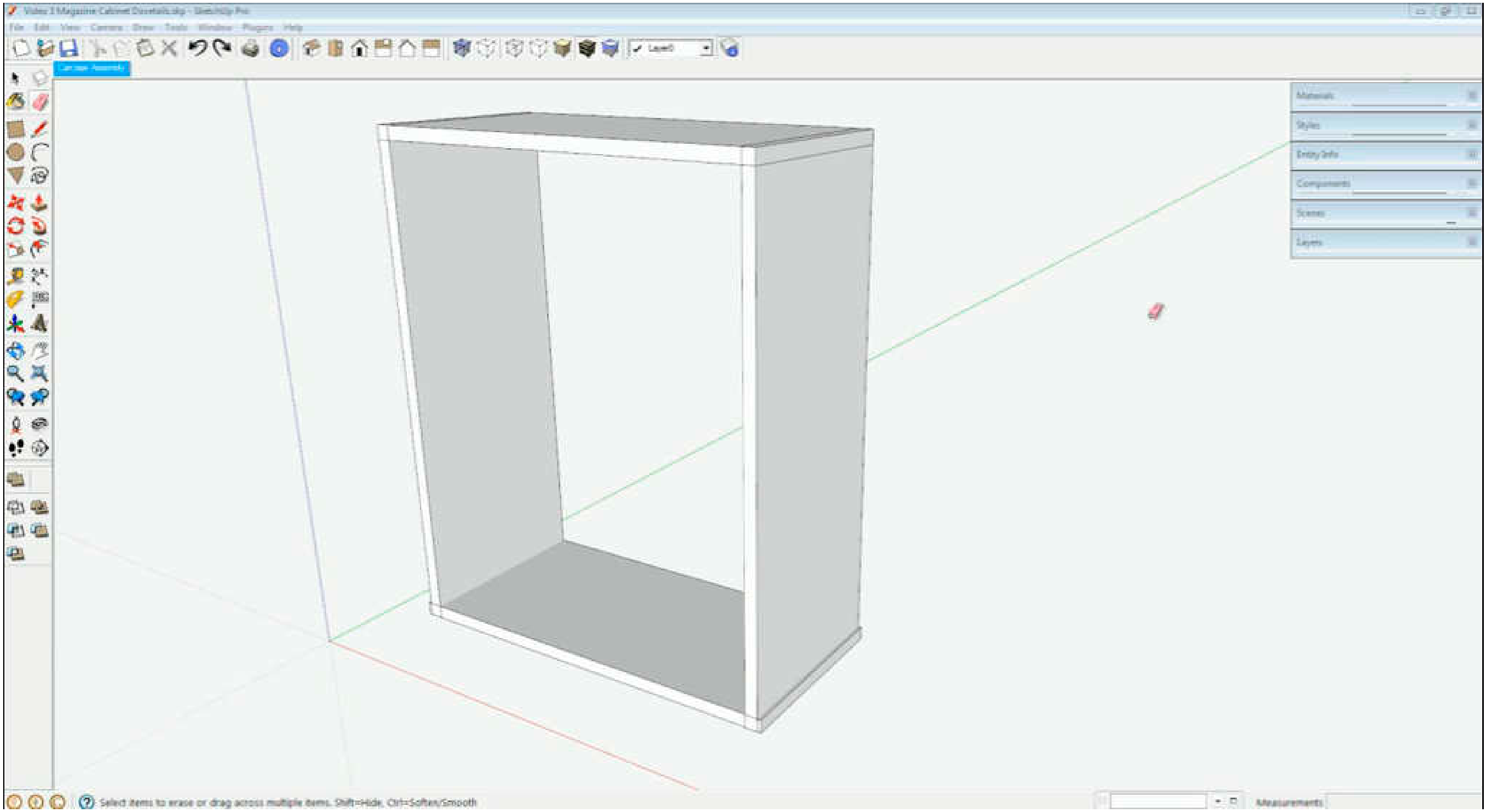


Figure 21. *The dimensions for the tails in the upper edge of the case side component. The mortise and grooves will be cut in a later step.*

Video Tutorial: Creating the Carcase Dovetail Joints

This video shows the steps needed to create the dovetail pins and tails in the top of the carcase.



Adding Dovetail Joints in the Top

To begin the dovetails, zoom in close to the upper corner of the case.

Step 8 Use the Tape Measure Tool to create a guideline ³⁄₁₆ in. from the front edge of the case-side component. Place another guideline ³⁄₁₆ in. from the back edge. These guidelines mark the midpoint of the two half-dovetails at the ends. See Figure 22.

With the Line Tool, draw a line between the two guidelines, following the green axis. Right-click on the line and choose Divide from the pop-up menu. See Figure 23.

Move the cursor along the line and click the mouse when reaching 6 segments. (A small box next to the cursor will tell you how many segments you are creating. Or, type 6 and press Enter.) See Figure 24. The divisions correspond to the number of tails in the dovetail joint, with each division marking the centerline of the waste between tails.

Step 9 Use the Tape Measure Tool to place additional guidelines parallel to the first pair that you drew. Each new guideline falls on a division point on the line. A small green dot will appear when you have reached that point. See Figure 25.

Place two additional pairs of guidelines on each side of the ones you just drew. One pair should be ⅛ in. from the centerline; the other pair, ¼ in. from the centerline. These guidelines help you mark the waste between the tails; obviously, the guidelines also size the dovetail pins, which are ½ in. wide at their thickest part and ¼ in. at their thinnest.

Step 10 Open the case-side component for editing. Use the Line Tool to create the

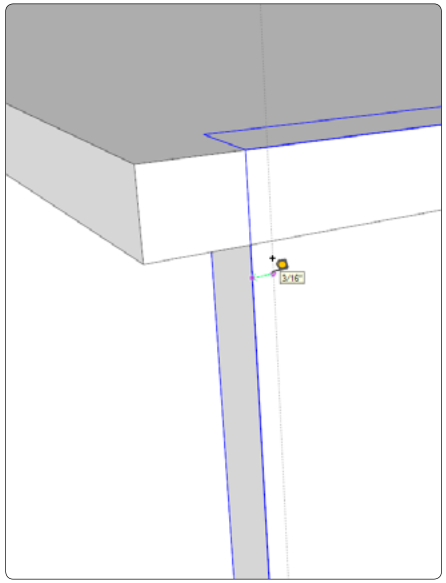


Figure 22. *Draw guidelines ³⁄₁₆ in. from the front and back edges of a side component.*

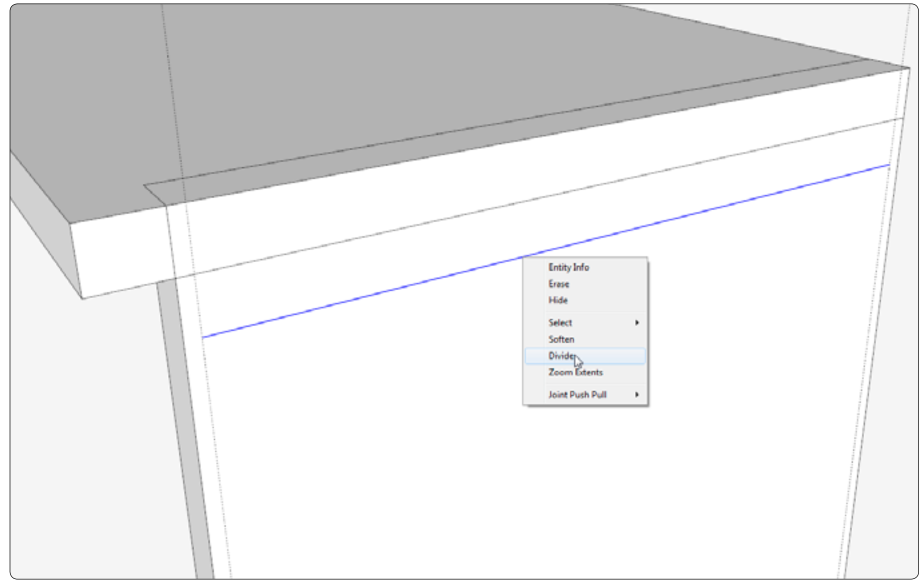


Figure 23. *Draw a line between the two guidelines, then divide it into equal segments.*

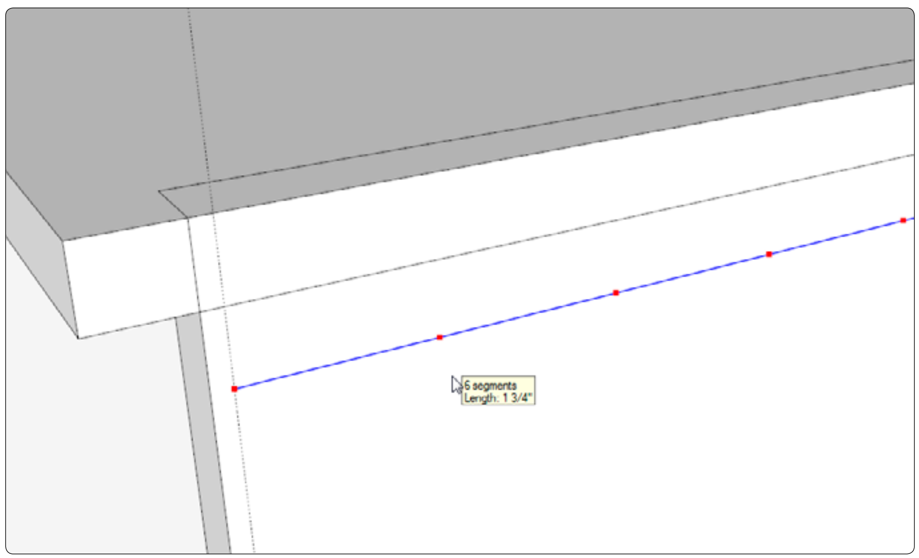


Figure 24. *Move the cursor along the line. Stop when you have divided it into six segments. A series of red dots will mark the divisions.*

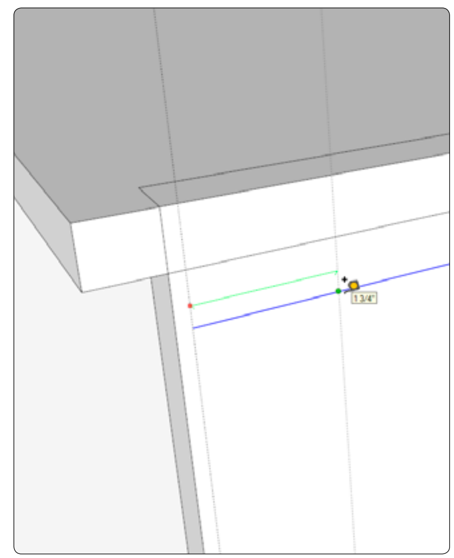


Figure 25. *Create a guideline at the end of the first line segment.*

shape of the waste between tails, using the guidelines to locate the endpoints of the sloped lines. See Figure 26.

Select the Push/Pull Tool and use it to remove the waste. Click on the back edge of the side component to stop the push/pull action, as shown in Figure 27.

Step 11 Switch to X-Ray from the Styles toolbar so you can see the complete shape of the waste. With the Select Tool, select the entire waste shape—front and back faces and the bottom, as shown in Figure 28.

Select the Move/Copy Tool and hover it over the waste shape until you land on the midpoint of the bottom. Tap the Ctrl key (Option on Macs) to copy the shape and move it along the green axis. Move the copy until you reach the centerline of the next waste shape. When reaching the proper place (a green dot will appear to alert you), click the mouse to place the copy. See Figure 29. Be sure to place waste shapes at the front and back of the side component for the half-dovetails, as shown in Figure 29.

Step 12 When you have placed all the waste shapes, delete the guidelines and the divided line. Click once on the side component to highlight it, then use the Move/Copy Tool to copy it and move the copy away from the model along the red axis. See Figure 30.

Clean up the half-dovetails at the ends. Zoom in to one end so you can clearly see the protruding angled edges and faces, as shown in Figure 31. This extra protrusion needs to be deleted, but before you do that, draw a line on the front edge of the case side component. This will ensure a clean deletion of the extra edges and faces. Clean up

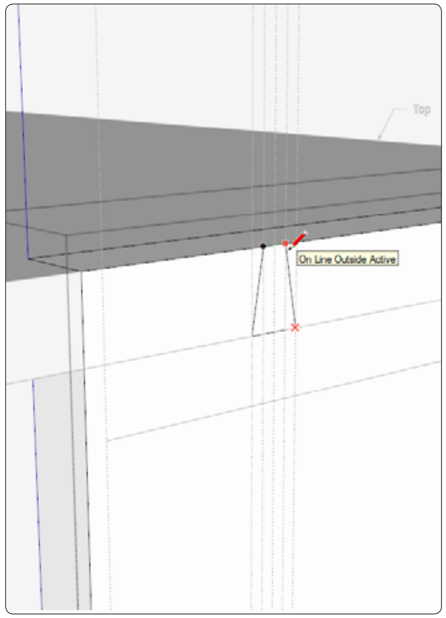


Figure 26. *Trace the shape of the waste between the tails, using the guidelines.*

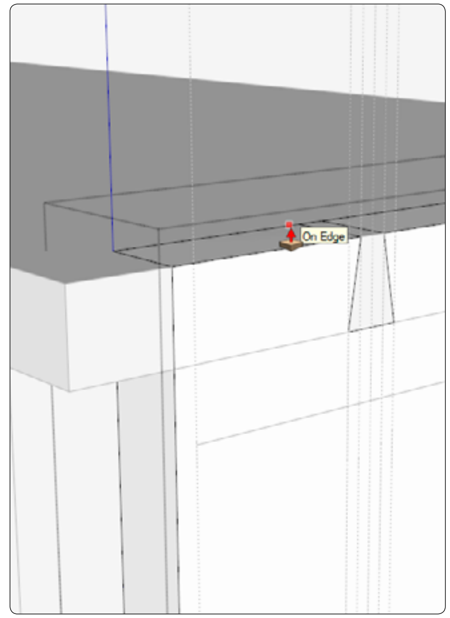


Figure 27. *Use the Push/Pull Tool to remove the waste between the tails.*

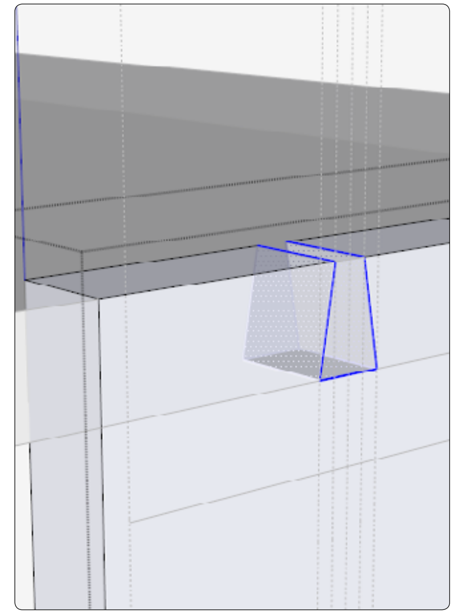


Figure 28. *Select all the faces and edges of the waste area.*

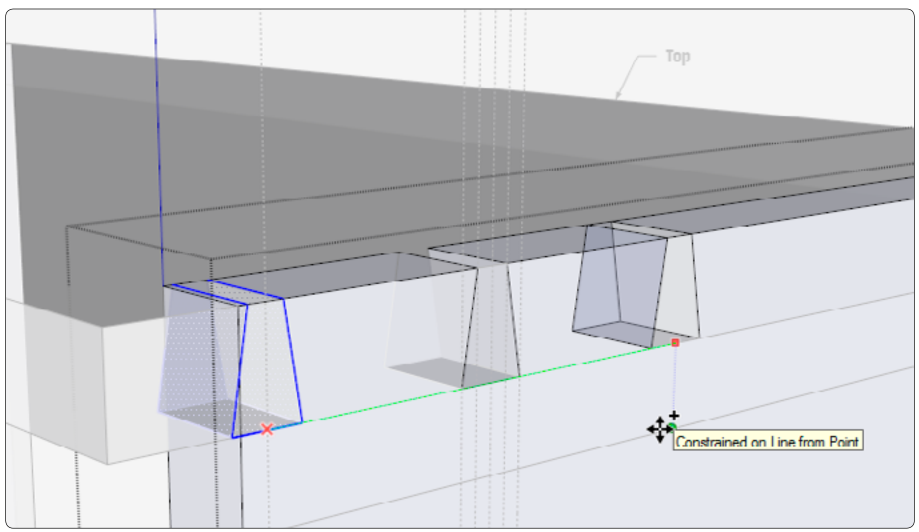


Figure 29. *Place copies of the waste area at each centerline, centering each one on a guideline to space them evenly.*

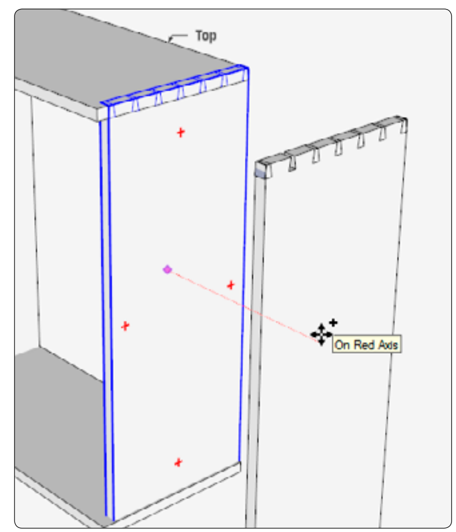


Figure 30. *Copy the Side component and move it away from the carcase.*

both half-dovetails. See Figure 32, Figure 33, and Figure 34. Delete the copy of the side component.

Step 13 Use the tails in the side component to create the pins in the top component. Open the top component for editing. Use the Line Tool to trace over the lines that define the pins, as shown in Figure 35.

Use the Push/Pull Tool to remove the waste between the pins, as shown in Figure 36. Figure 37 shows the completed dovetails.

Copy the dovetails on this end of the top component and place them on the other end using the Move/Copy Tool. Select the entire set of dovetails, copy and execute a flip along component's red command, and connect them to the other end of the top component.

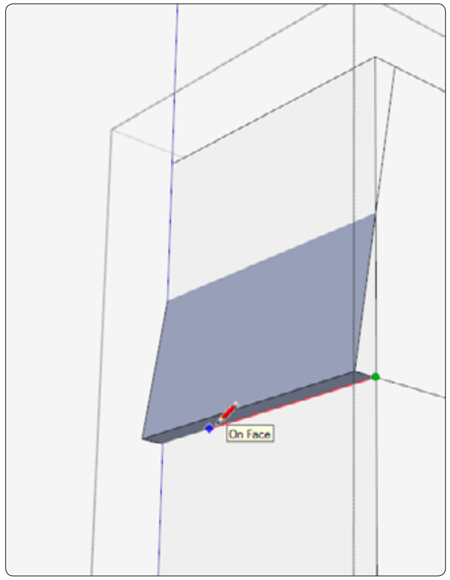


Figure 31. *Draw a line on the front edge of the side to help erase waste cleanly.*

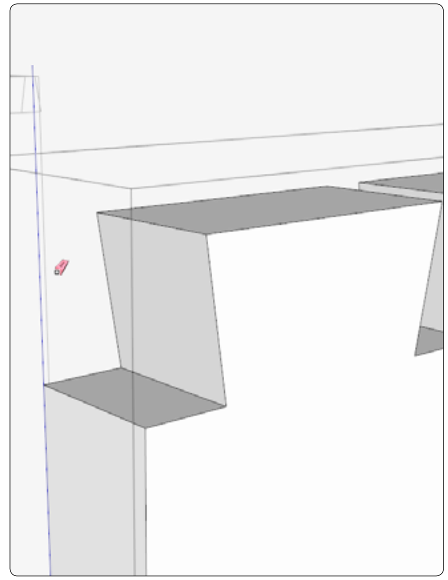


Figure 32. *This shows the half-dovetail after clean-up with the Eraser Tool.*

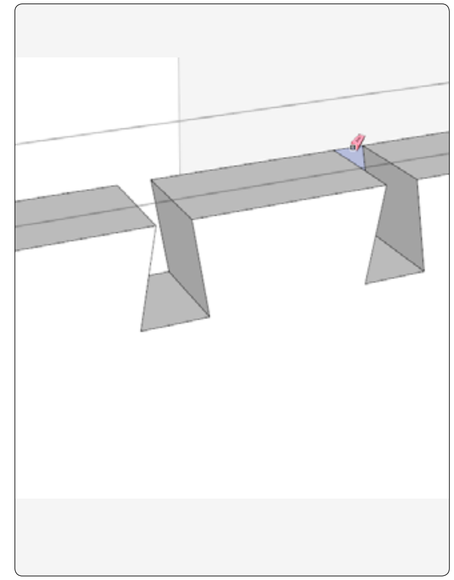


Figure 33. *Use the Eraser Tool to delete extra edges between the tails.*

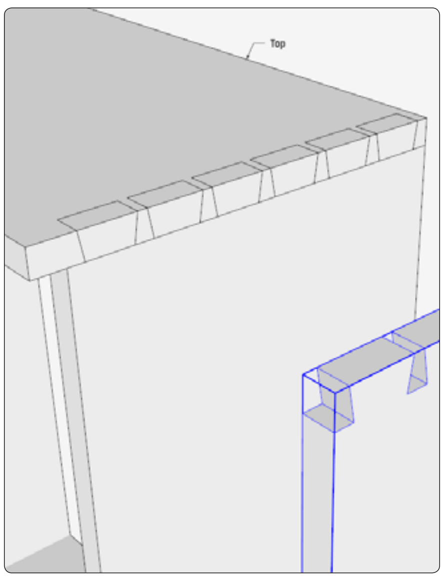


Figure 34. *The completed dovetail sockets in the carcase side.*

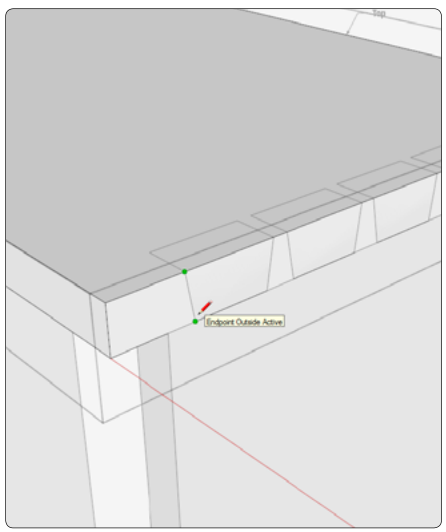


Figure 35. *Open the top component and-draw the lines that shape the pins.*

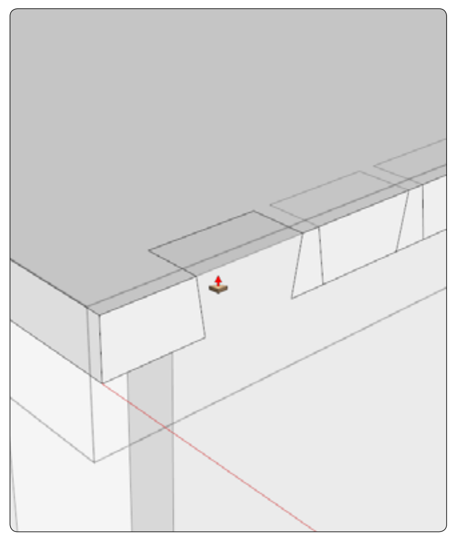


Figure 36. *Use the Push/Pull Tool to remove waste between the pins.*

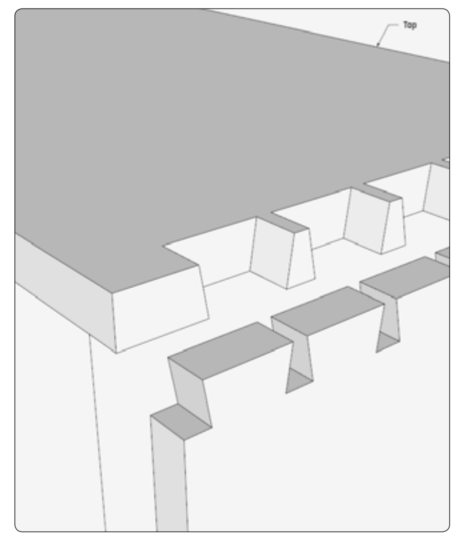


Figure 37. *This shows the completed pins and tails in the top and side components.*

Section 3. The Mortise-and-Tenon Joints

In this section we'll make the joints in the bottom of the cabinet carcase. Because the bottom component extends past the sides, dovetails are not an option. Instead, the bottom is held in place with a wedged mortise-and-tenon joint, which is also a strong joint.

We'll introduce you to another new SketchUp tool: the Protractor. Among many other uses, the Protractor Tool helps make temporary angled guidelines.

In the shop, you'll want to avoid pounding in the wedges too forcefully. That's because the wedges run parallel to the grain in the bottom, so there is a risk that the wedges could split the bottom. Normally, you would want the wedges to run across the grain of the mating piece, but that's not possible with this case design.

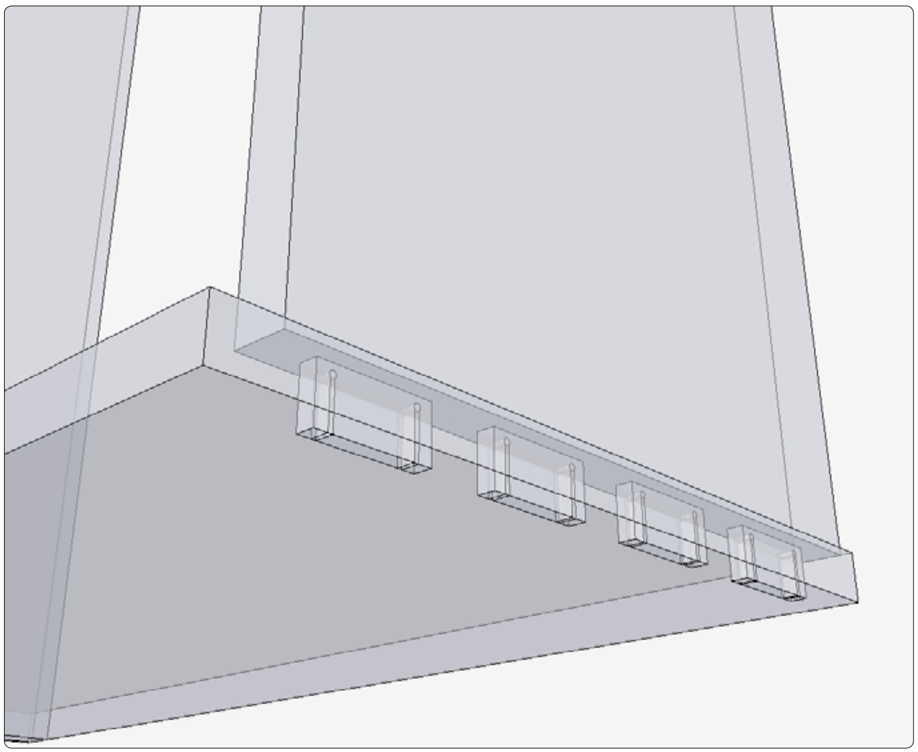


Figure 38. An X-Ray view of the mortise-and-tenon joints.

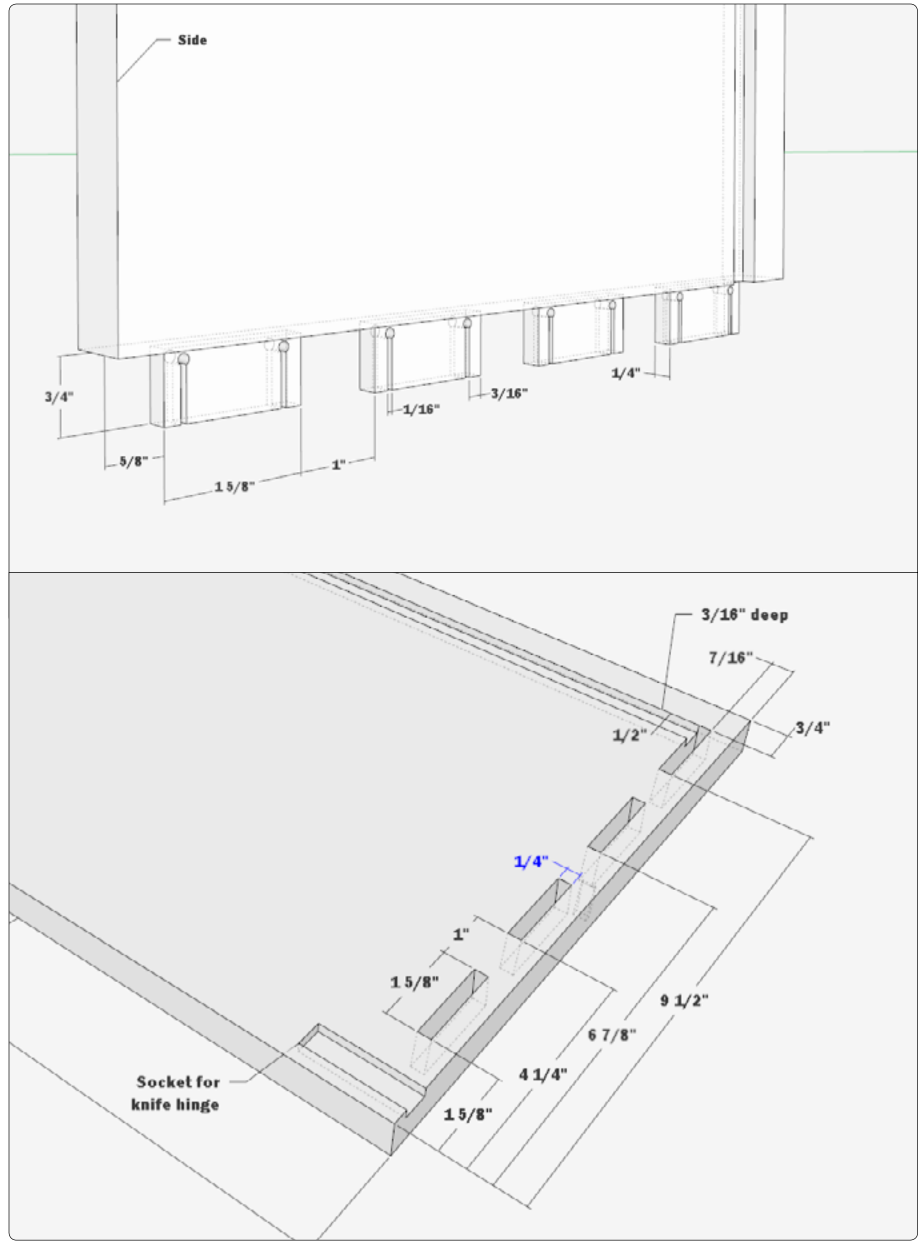


Figure 39. The dimensions and spacing for the mortise-and-tenon joints.

The Mortise-and-Tenon Joints

Instead of dovetail joints in all corners, this carcase uses through mortises and wedged tenons to connect the bottom and side components. The tenons have a pair of saw kerfs at each end to house the wedges. The kerfs do not extend all the way to the tenon shoulder, but end at a small hole drilled in the tenon. The mortises have sloped ends, allowing the tenons to expand as the wedges are driven deeper into the saw kerf. Figure 38 shows the completed joint, and Figure 39 gives the necessary dimensions.

Step 14 Begin by making the tenons on one case-side component. Open the side component for editing and draw a line around the side where it intersects with the bottom component. See Figure 40. This defines the shoulder location for the tenon.

Create a copy of the case-side component and pull it away from the carcase assembly, as shown in Figure 41.

Step 15 Place parallel vertical guidelines on the face of the case-side component to mark the 1⅝-in. width of the tenons and the 1-in. gap separating them. See Figure 42. Trace over one set of guidelines to define the shape of the first tenon and the waste next to it.

Use the Push/Pull Tool to remove the waste on either side of the tenon, as shown in Figure 43.

Step 16 Next, you will add the saw kerfs and holes to the tenon, then copy it three times along the width of the case-side component. This ensures that all the tenons are identical. The 1⁄16-in.-wide saw kerfs are 3⁄16 in. from each end of the tenon. Use the

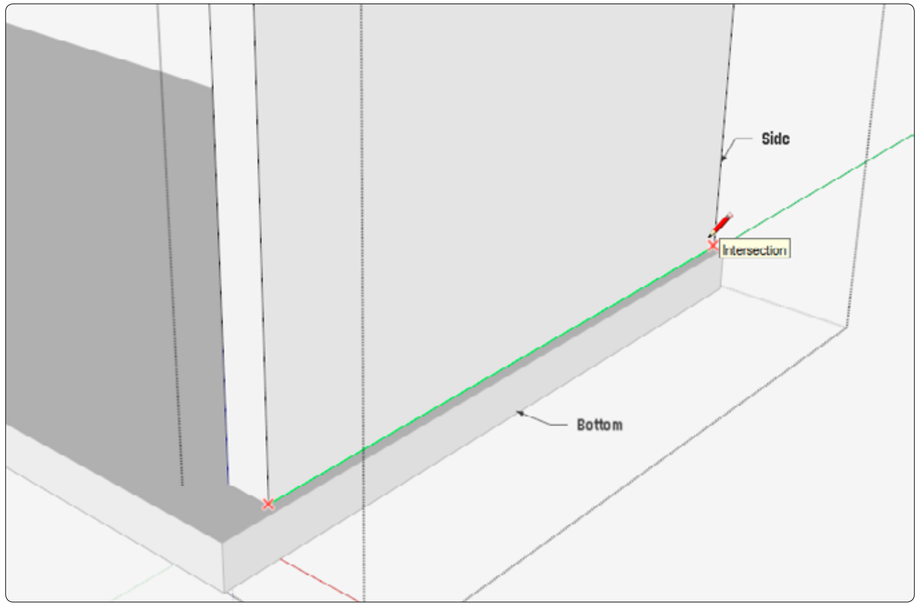


Figure 40. *Begin the joinery by drawing a line around the side component where it intersects with the bottom. This establishes the tenon shoulder.*

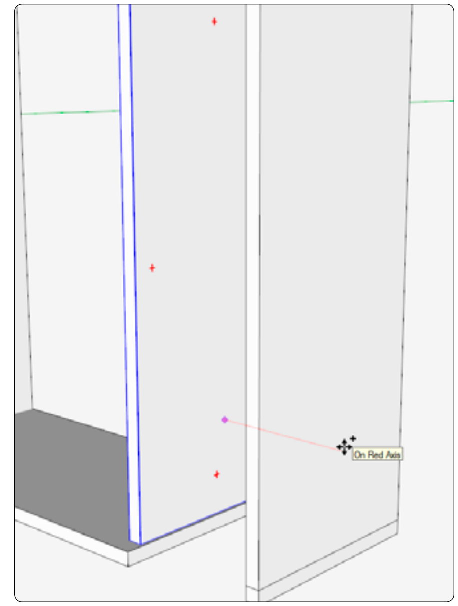


Figure 41. *Pull a copy of the side away from the carcase assembly.*

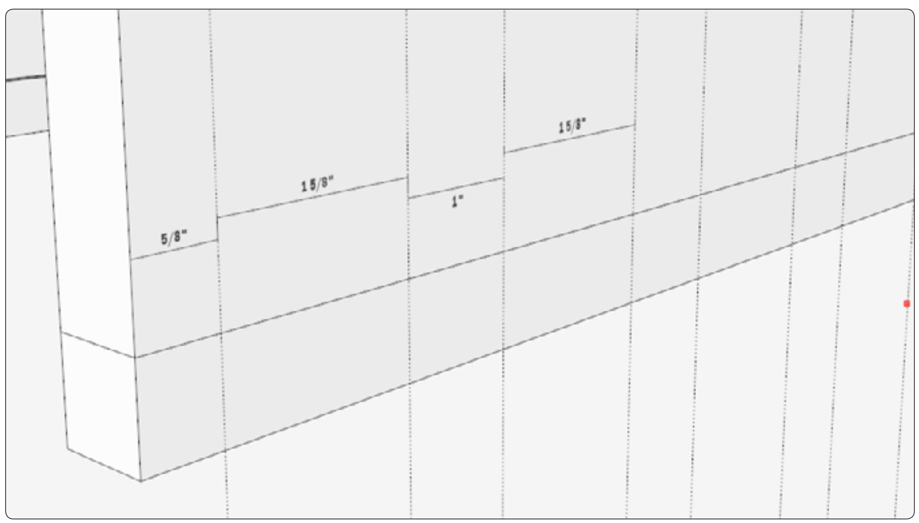


Figure 42. *Place vertical guidelines on the side to establish the width of the tenons and the space between them. Draw one tenon, tracing over the guidelines.*

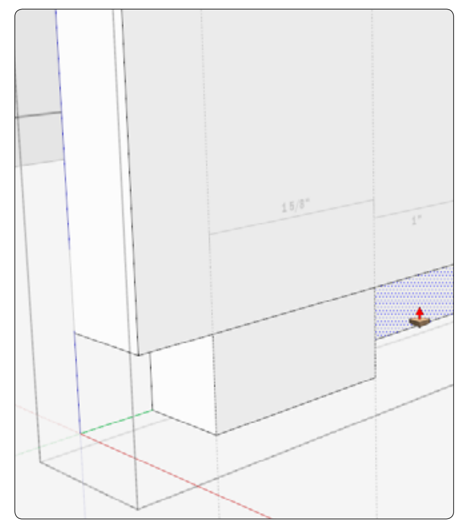


Figure 43. *Push out the waste to make one tenon shape.*

Tape Measure Tool to create guidelines locating the kerf, as shown in Figure 44.

Use the Circle Tool to draw the circle for the a kerf-terminating hole. I made it ⅛ in. in diameter and placed its center about ⅛ in. down from the tenon shoulder line. See Figure 44. The exact size and position of the circle aren't critical, as long as the circle is wider than the saw kerf and does not touch the tenon shoulder.

Use the Eraser Tool to remove the portion of the circle that crosses the saw kerf, leaving an elongated keyhole shape.

Step 17 With the Select Tool, double-click inside the kerf shape to highlight it. Use the Move/Copy tool to copy the shape and place it at the other end of the tenon, on the guideline you drew previously. Then use the Push/Pull Tool to remove waste from the shapes, as shown in Figure 45.

Step 18 Use the Select Tool to draw a selection box from left to right around the entire tenon shape. See Figure 46.

Choose the Move/Copy Tool and tap the Ctrl key (Option on Macs) to copy the tenon. Move the copy along the green axis and place it at the appropriate guideline. Repeat the copying two more times to place the remaining tenons. See Figure 47.

Step 19 Now, pare down the tenons to their final thickness of ¼ in. Use the Push/Pull Tool to push the face of each tenon toward the center of the case-side component by ¼ in. Begin the Push/Pull movement on the first tenon, type ¼, and press Enter. Then hover the Push/Pull tool over the face of the next tenon and double-click to repeat the

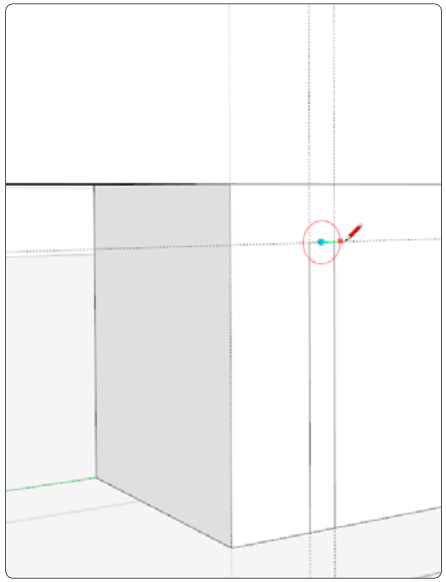


Figure 44. *Shape the kerf and draw the circle near the tenon shoulder line.*

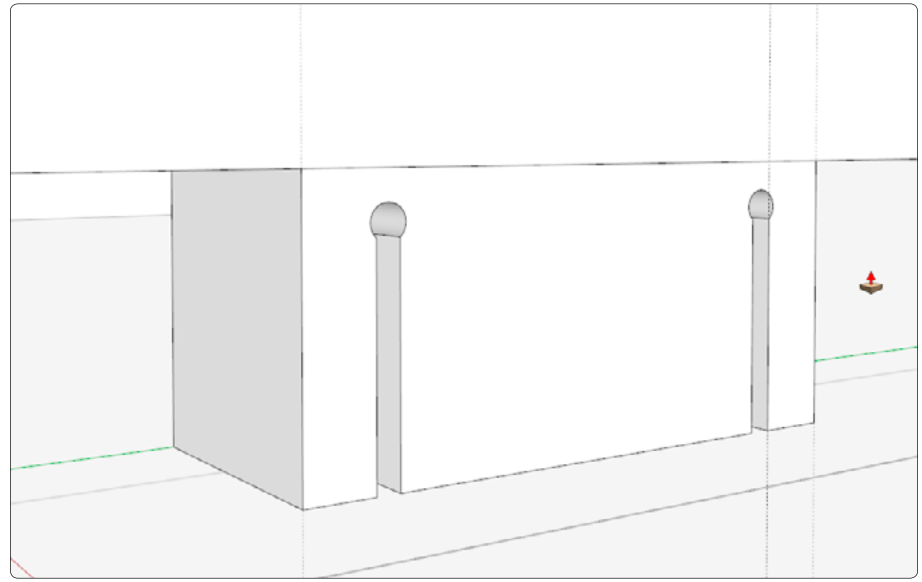


Figure 45. *Copy the kerf and place it at other end of the tenon, at the guideline. Use the Push/Pull Tool to remove waste from the kerf shapes.*

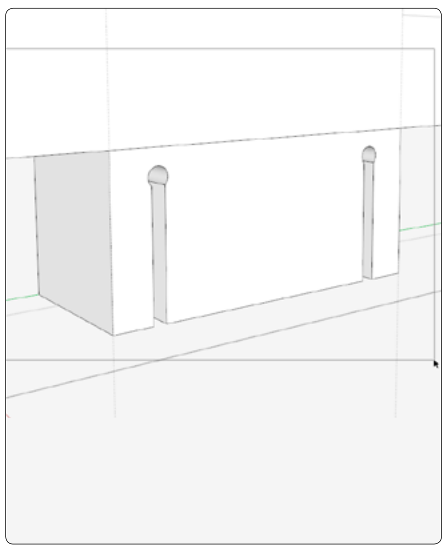


Figure 46. *Select the entire first tenon for copying.*

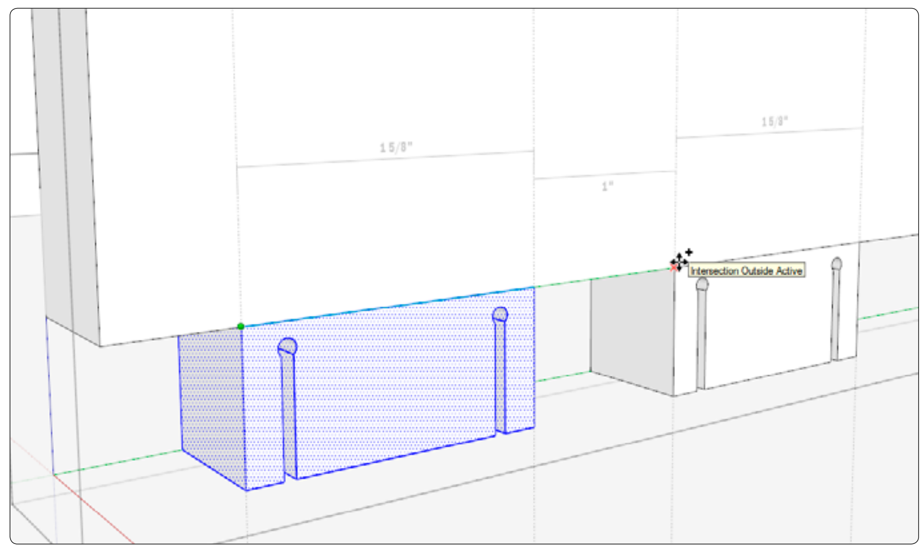


Figure 47. *Place three copies of the tenon at the appropriate guidelines.*

movement. Continue until you have thinned both sides of the tenons. See Figure 48.

Delete the copy of the side component.

Step 20 Just as you used the tails to draw the dovetail pins, you will use the tenons to lay out the mortise locations.

Zoom in close to the lower front corner of the case assembly. Orbit the model so you can see the bottom face of the bottom component. See Figure 49. You will see the outlines of the tenons as they show up on the bottom face. Open the bottom component for editing. Use the Line Tool to trace around the rectangular shapes of the tenons. After creating the rectangles, use the Push/Pull Tool to push the mortise shape through to the top face of the bottom component. See Figure 49.

These mortises now match the shape of the tenons. You will modify the mortises to give them a trapezoidal shape to accommodate the wedges.

Step 21 Copy the bottom component and move it away from the assembly. Orbit around to see the component's top face, as shown in Figure 50.

Choose the Protractor Tool and center it on one corner of the tenon. Click on the corner to anchor the protractor at that point. See Figure 50. The color of the protractor should be red. This tells you its center is aligned with the red axis.

When the Protractor Tool is anchored, move the mouse toward the top of the screen; you will see a blue dashed line, indicating that you are moving along the blue axis. Click again and begin moving the mouse to the right. Type 6 and press Enter. This creates a guideline 6 degrees from the vertical, defining the slope on the sides of the mortises.

Draw another angled guideline, centered on the opposite corner of the mortise; this time, angle it to the left. See Figure 50.

Step 22 Orbit so that you can see the bottom face of the bottom component. You will see the angled guidelines extending through the face. With the Tape Measure Tool, double-click on the edge of the mortise to create an in-line guideline that intersects the angled guidelines. See Figure 51.

The rectangular opening in the bottom surface will be longer than the shape at the top surface; the angled guidelines tell you how much to enlarge the shape.

Use the Line Tool to extend the rectangle shape out to the intersection of the angled

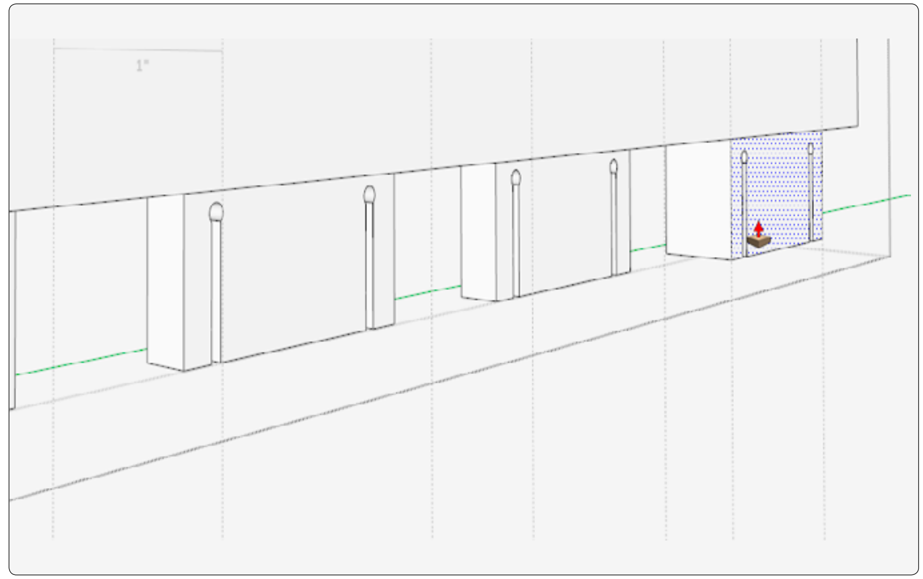


Figure 48. *Use the Push/Pull Tool on both faces of the tenons to thin them to their final thickness of ¼ in.*

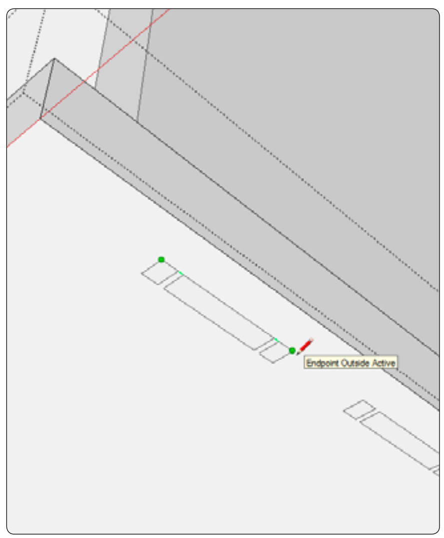


Figure 49. *Trace around the perimeter of the tenons on the face of the bottom.*

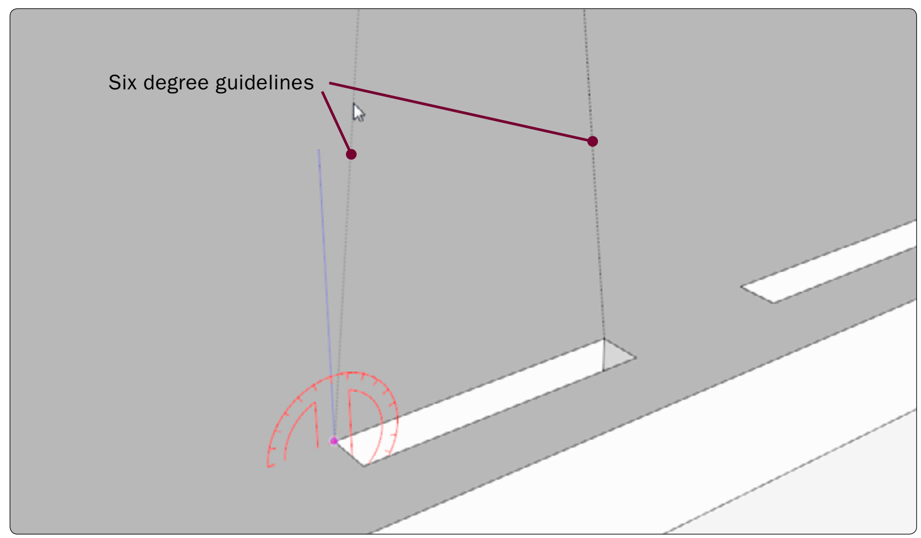


Figure 50. *Use the Protractor Tool to draw a pair of angled guidelines at two corners of the mortise. The guidelines establish the slope of the mortise sides.*

guides and the in-line guide. Continue drawing to enlarge the ends of the rectangle. See Figure 52. Use SketchUp's inferences to tell you when to change direction with the line.

Step 23 Switch to X-Ray view so you can see into the center of the mortise. Draw angled lines to connect the corners of the mortise on the top face with the enlarged opening on the bottom face. See Figure 53. Use the Eraser Tool to remove the extraneous lines, as shown in Figure 54.

Step 24 With the model still in X-Ray view, copy the finished mortise over to the other mortise locations. Use the Eraser Tool to remove extraneous lines.

Step 25 Return to normal view. Draw a selection box from left to right around all the mortises. Use the Move/Copy tool to copy and move them to the opposite end of the bottom component. Execute a flip along red direction command, then connect the copy to the rest of the component. To remove waste from the faces of the mortises, draw a line partway along one edge of the mortise, then delete the face inside the shape.

Step 26 Finally, create the tenon wedge, following the dimensions shown in Figure 56. Draw a rectangular face ⅛ in. by ¾ in. Select the Protractor Tool, click it on the lower left hand corner, then make a 6 degree guideline. Draw a line along the guideline to establish the taper on the wedge. Use the Eraser Tool to remove extraneous lines. Then, with the Push/Pull Tool, make the wedge ¼ in. thick. Use the Move/Copy Tool to position the wedge in the tenon's saw kerf.

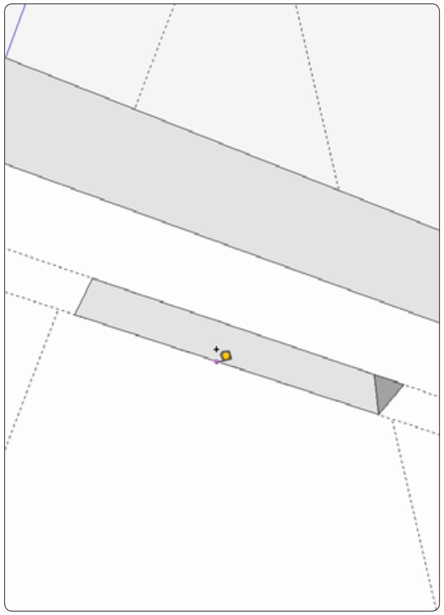


Figure 51. *A view of the bottom face with angled guidelines protruding.*

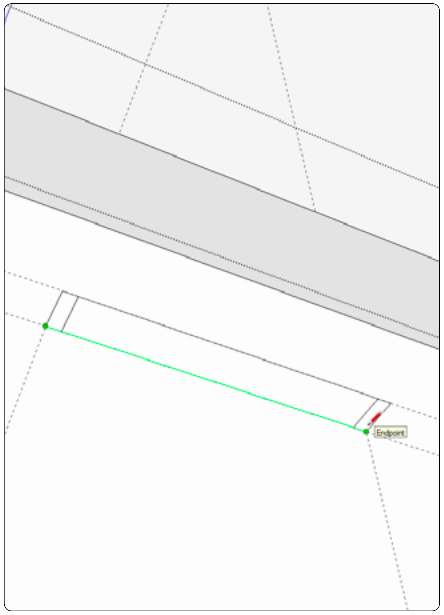


Figure 52. *Draw a rectangle from the intersections of the guidelines.*

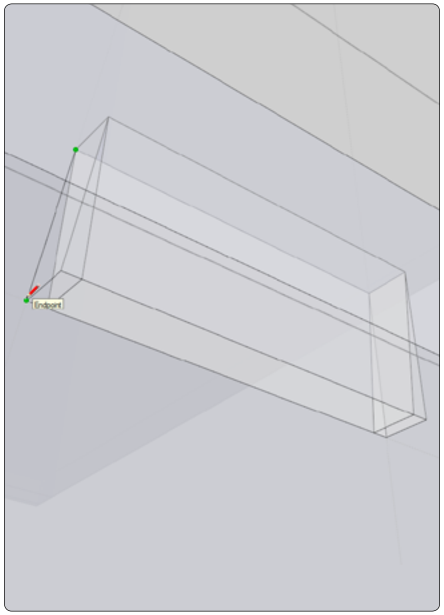


Figure 53. *Draw angled lines for the slope of the mortise.*

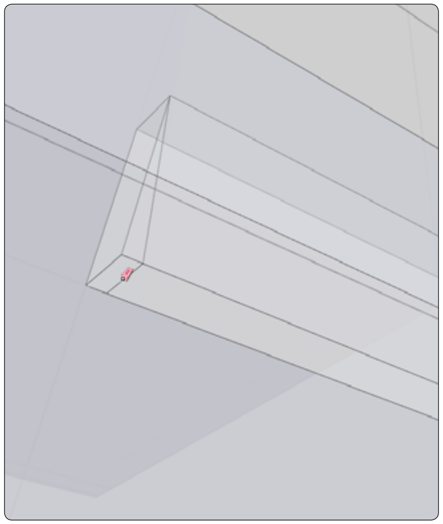


Figure 54. *Use the Eraser Tool to remove extra lines.*

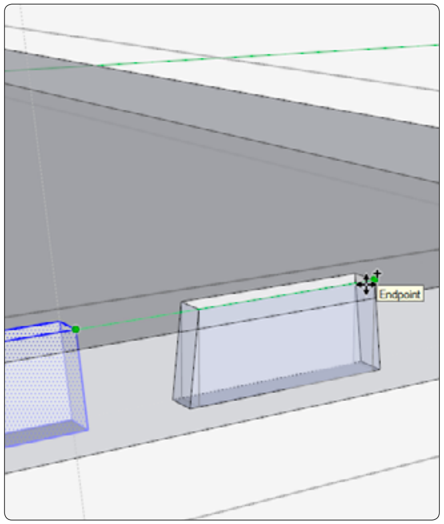


Figure 55. *Copy the finished mortise to the remaining three locations.*

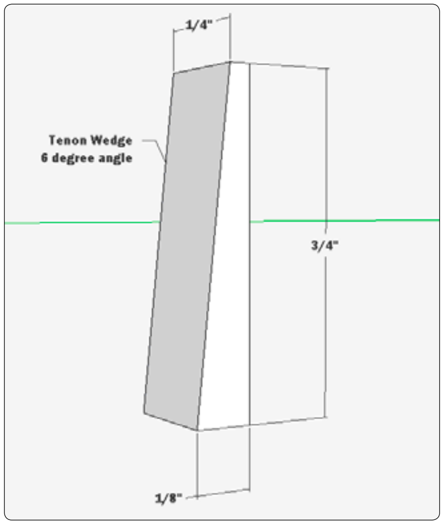


Figure 56. *The tenon wedge. Each tenon requires two of these.*

Status Report

Figure 58 shows the construction status for the wall cabinet now that you have completed the strong carcase joinery. It's too soon for glue-up in actual construction, because several more grooves, joints, and parts must still be created. The back panel and hanging cleat need to be installed prior to glue-up. The interior parts will be installed during glue-up.

The pieces of the carcase have a common grain direction, which contributes to the structure's stability and strength because the pieces move consistently with seasonal changes in temperature and humidity. That helps the corner joints remain strong.

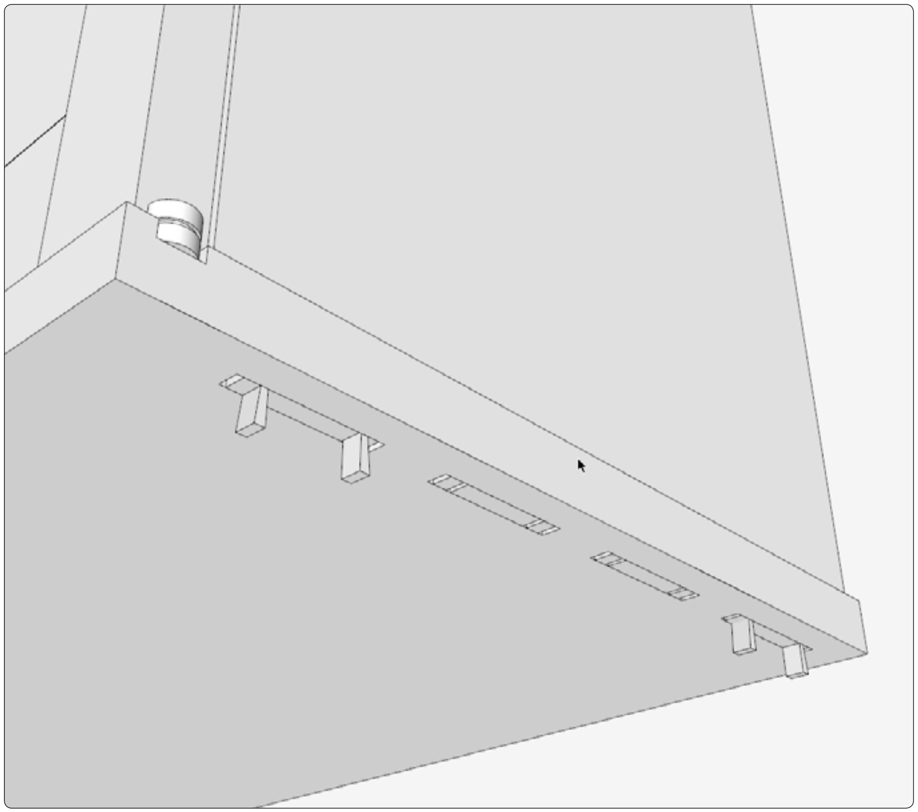


Figure 57. *Wedges inserted partway into two of the four mortises.*

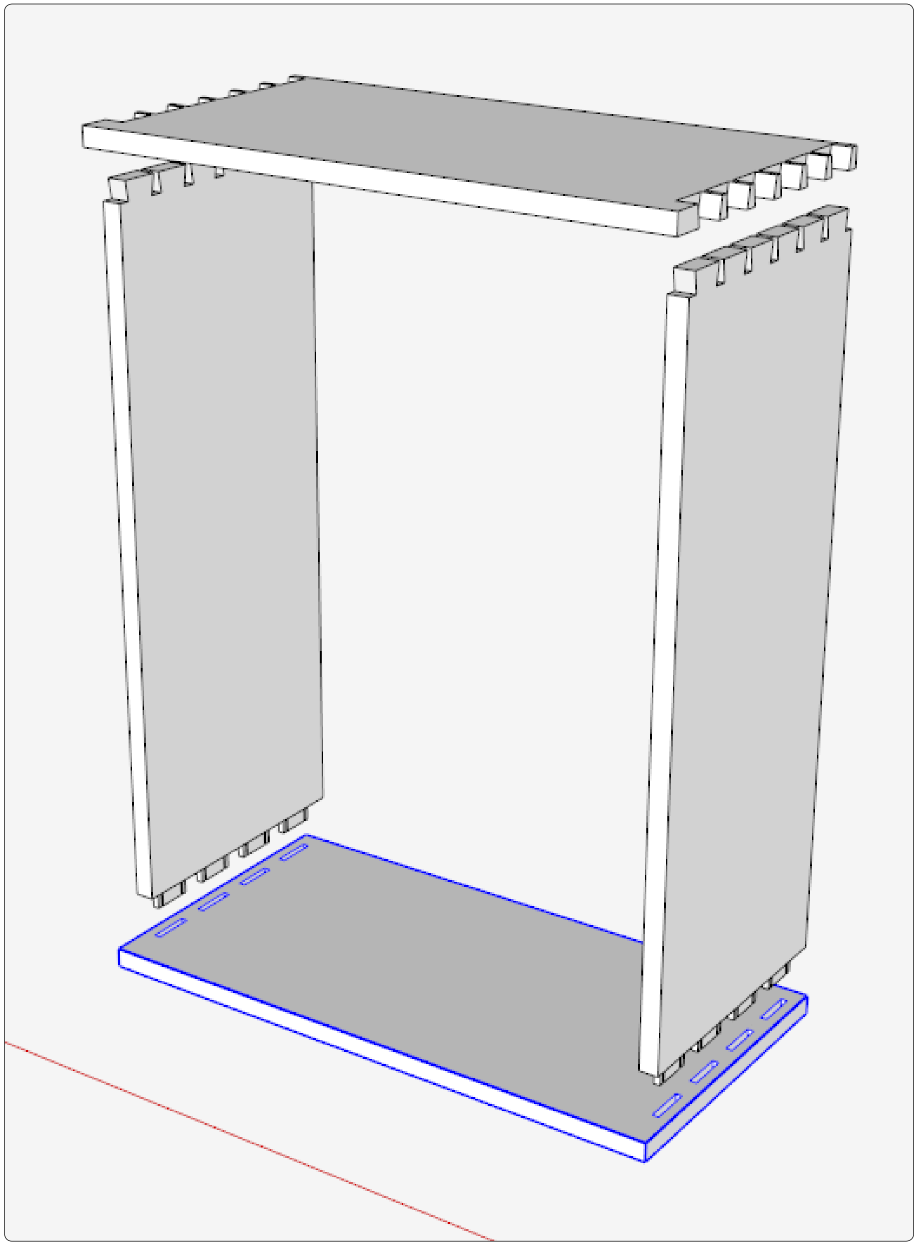


Figure 58. *An exploded view of the construction so far, showing the completed corner joints.*

Section 4. Creating the Back Panel

In this section we'll make the back panel. In my experience, the back panel is one of the last pieces made in the shop. It is usually installed in an open rabbet on the back of the carcase. But in this piece, the back panel will be recessed and held in a groove within the carcase. This creates room for the French cleat.

Many of the techniques covered in this section also apply to the construction of the door. Both assemblies use mortise-and-tenon joinery for the frame, with a floating panel or panels in the center.

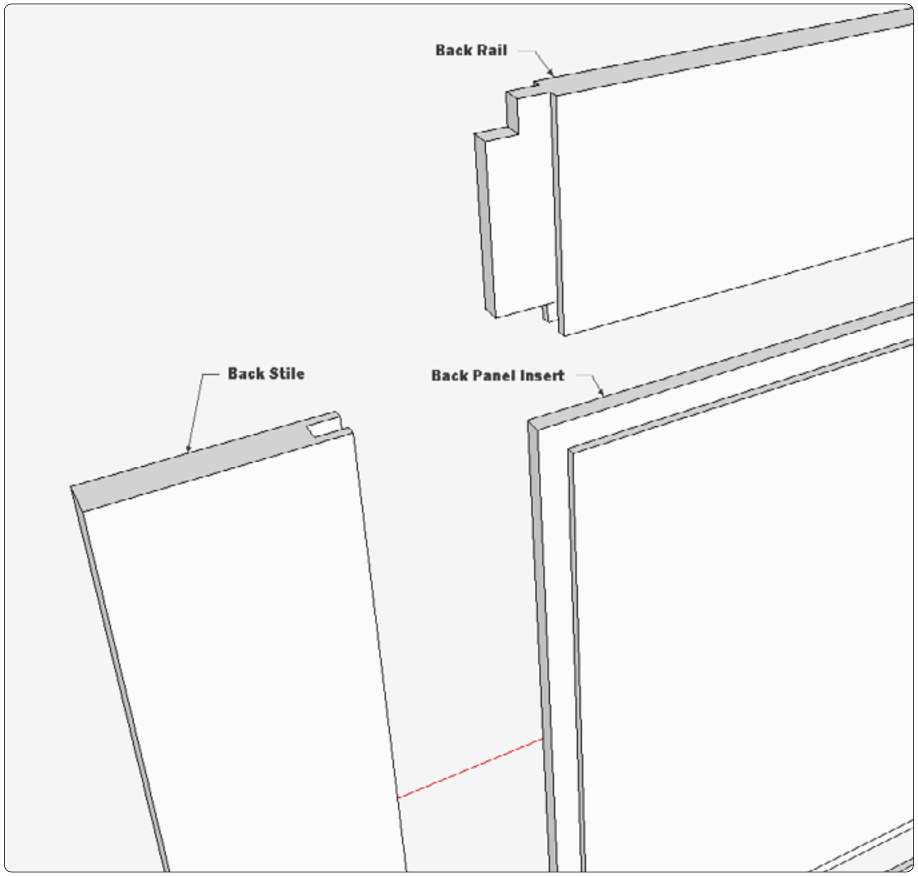


Figure 59. *The upper corner of the back panel disassembled.*

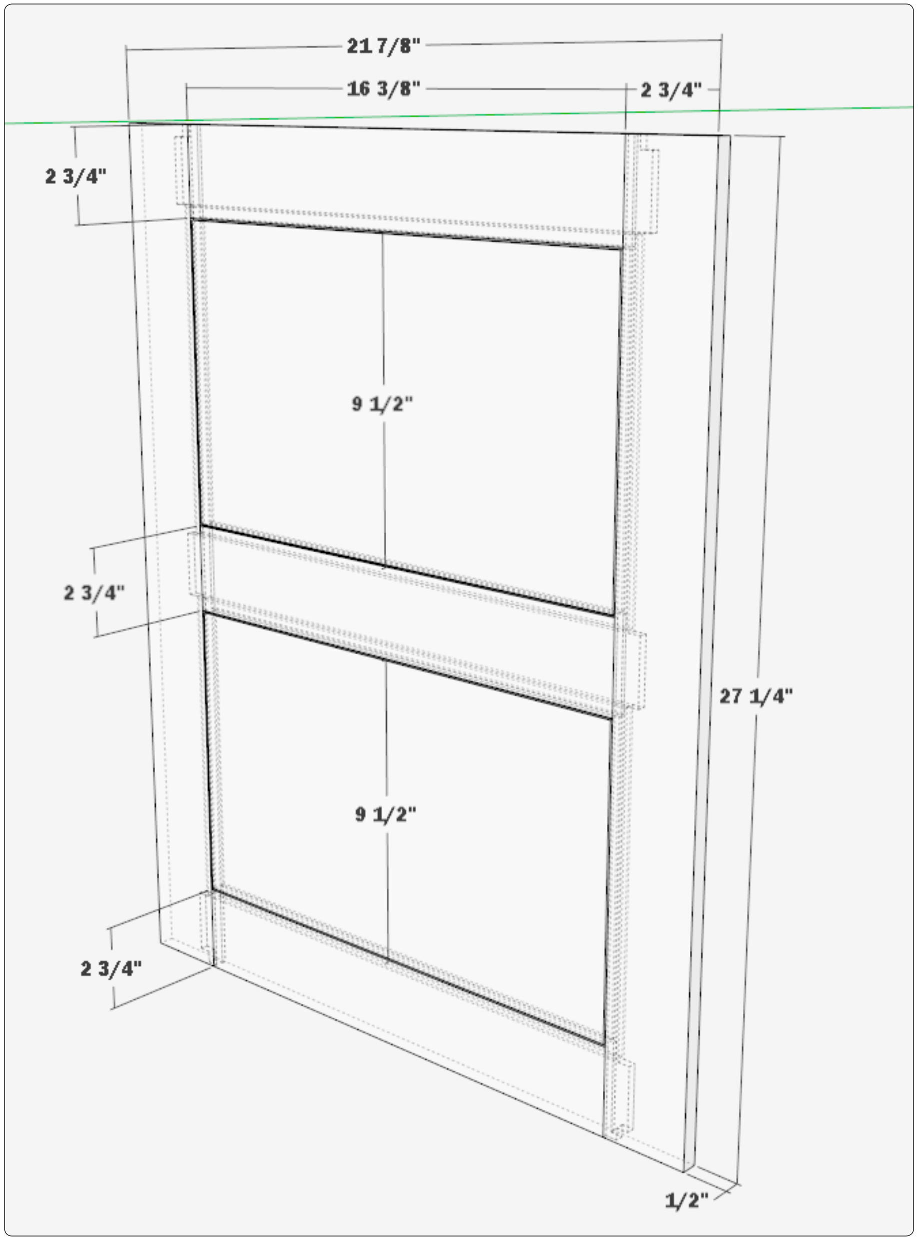
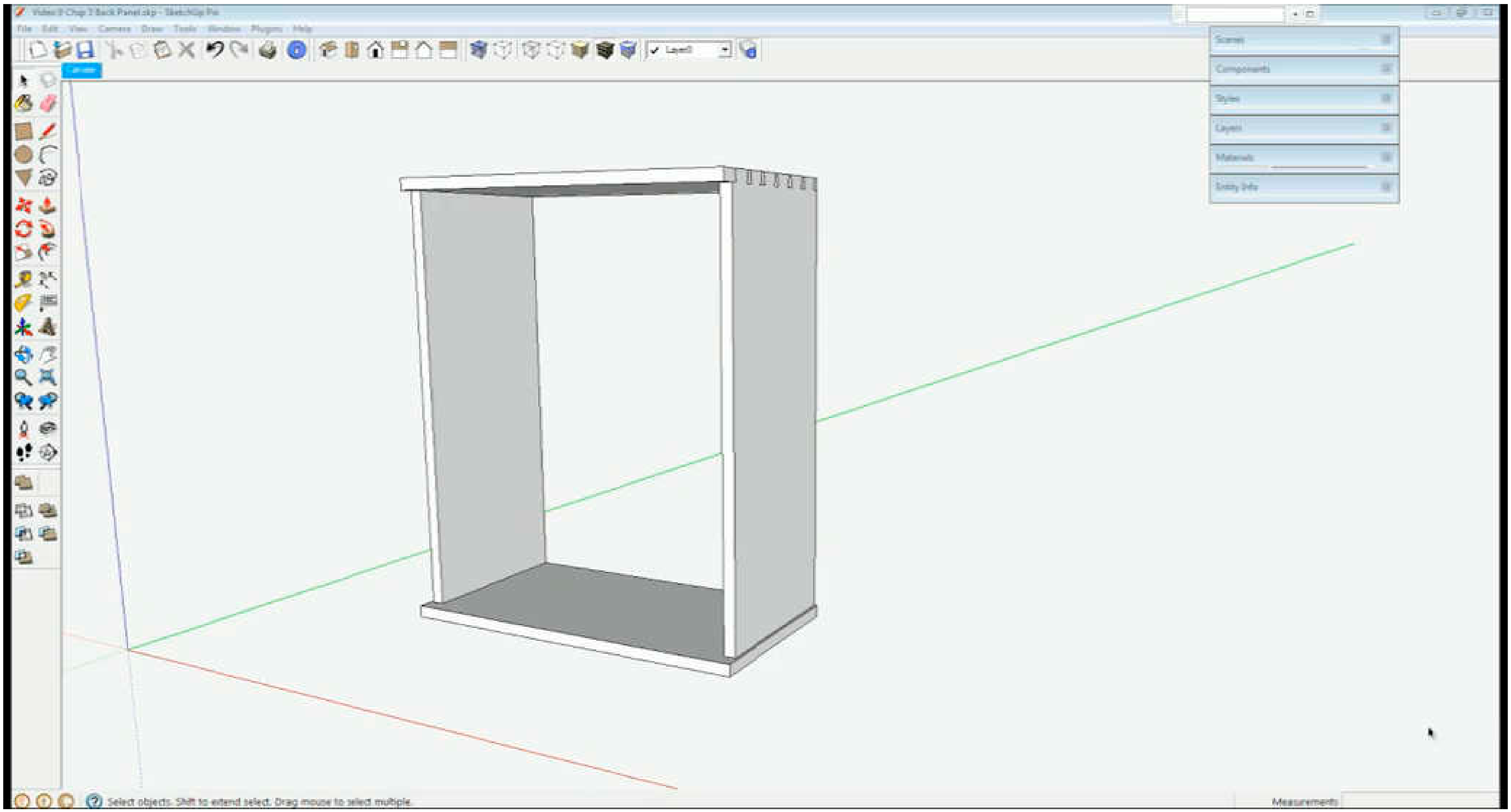


Figure 60. *The assembled back panel.*

Video Tutorial: Creating the Back Panel

This video shows one common method for creating the frame and insert for the back panel assembly. It ensures that the parts of the back panel are the proper size and oriented correctly. The text on the next few pages presents a slightly different way to make this part of the cabinet. Both methods work well. Together, they show how there is often more than one way to accomplish something in SketchUp.



Creating the Back Panel

The back is often one of the last pieces to fit in place. On this cabinet, though, the French cleat will fit into sockets in the sides of the carcase. That means the back must be made and installed along with the cleat when you glue up the carcase.

The back panel rests in a groove cut in the sides, top, and bottom of the carcase.

This back panel is made in a traditional manner, with horizontal rails, vertical stiles, and two floating solid-wood panels. Mortise-and-tenon joints connect the rails and stiles. The floating panels are ½ in. thick, rabbeted around their edges to fit within a groove in the frame pieces.

A cabinet's back panel must be very stable, without growing and shrinking with changes in weather and indoor environment. In this cabinet, the groove holding the floating panels gives them room to shrink and expand without affecting the overall size of the back panel.

Step 27 Begin by drawing a rectangular shape that is ½ in. by 2¾ in. for the back rail, as shown in Figure 62. Use the Push/Pull Tool to make the piece 16⅜ in. long, which is the space between the stiles. Make the piece a component. You will add the tenons in the next step.

Step 28 The tenons in the back rail have a ⅜-in. x ⅜-in. haunch that fills the groove in the stiles. Using the Tape Measure Tool, set guidelines for the tenon thickness of ¼ in., the height of the haunch, and the width of the tenon, as shown in Figure 63. Trace over those guidelines with the Line Tool and use the Push/Pull Tool to create the ⅜-in.-long

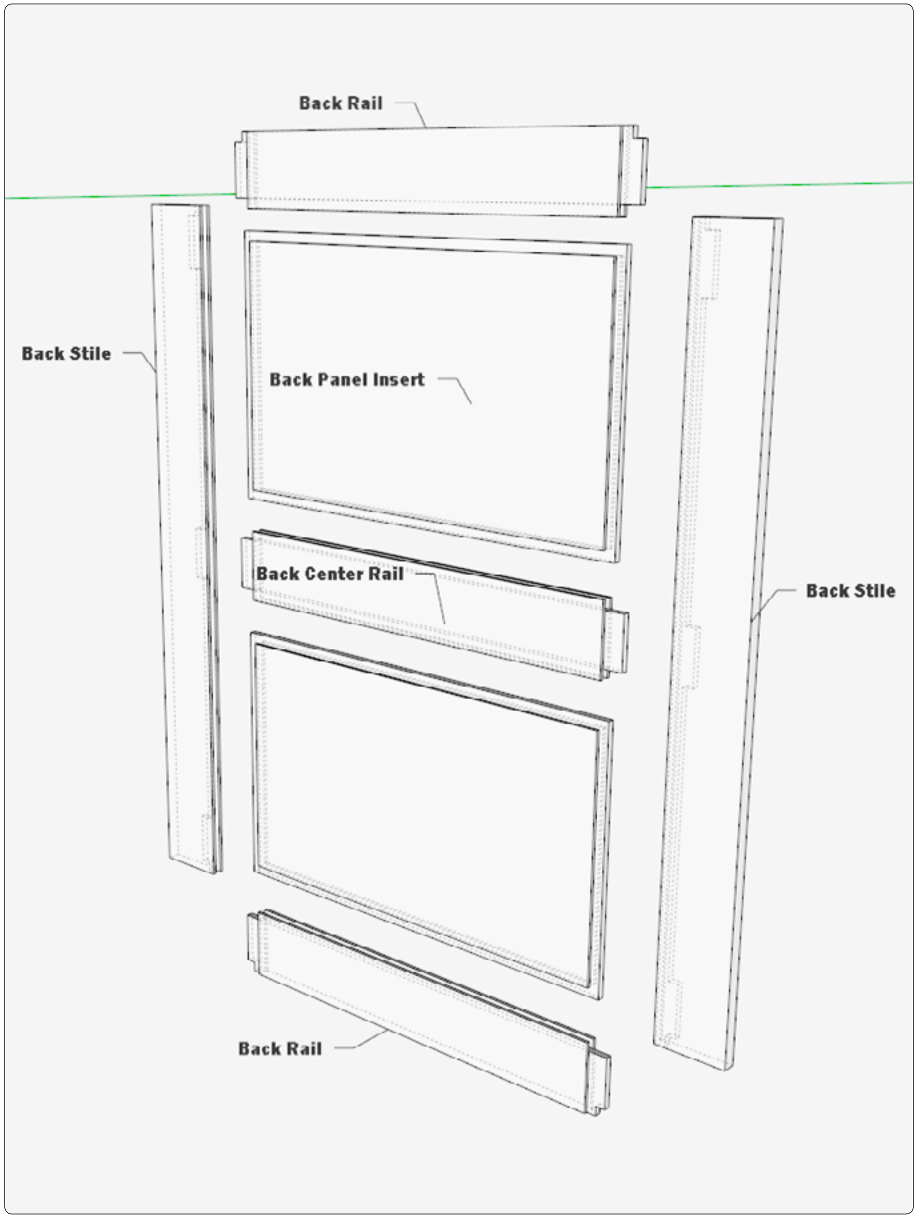


Figure 61. *An exploded view of the back panel.*

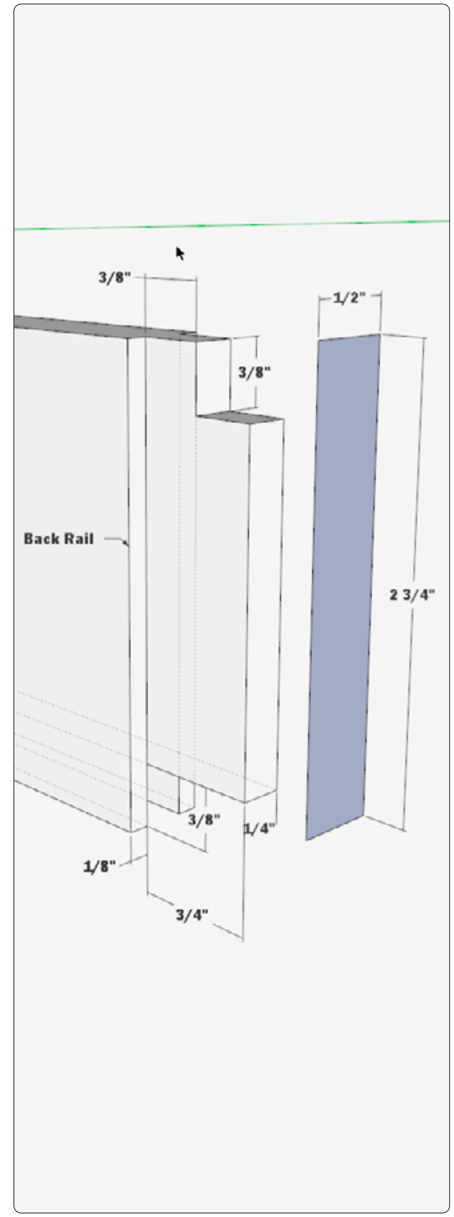


Figure 62. *Dimensions for the back rail tenon. The rectangle is the rail's shape.*

haunch and ¾-in.-long tenon. See Figure 64. Copy the tenon to the other end of the back rail. Be sure to do a flip along command to orient the tenon properly. To complete the back rail, use the Push/Pull Tool to create the groove along one edge.

Step 29 To make the vertical stile, draw a rectangle 2¾ in. wide by 27¼ in. long. Use the Push/Pull Tool to give it a thickness of ½ in. Make the stile a component.

Orbit and zoom so that you have a good view of the end of the stile. With the Tape Measure Tool, place guidelines to define the size of the groove: ¼ in. wide and ⅜-in. deep. See Figure 65. Use the Line Tool to trace over the shape of the groove and push out the groove with the Push/Pull Tool.

Step 30 To create the mortise in the stile, connect the back rail to the stile, as shown in Figure 66. Open the stile for editing, turn on X-Ray view, and trace over the short horizontal lines created by the long part of the tenon as it intersects the bottom of the groove in the stile. You may need to orbit and zoom very close to see the lines clearly. With the Push/Pull Tool, push out the mortise and stop it at the end of the tenon. See Figure 67.

Step 31 Copy the back rail, flip it along the blue axis, and connect it to the lower end of the Stile. Repeat the procedure in Step 30 to make the mortise.

Step 32 Make the middle rail from another copy of the back rail component. When you make the copy, right-click on it and choose Explode from the pop-up menu; right-click

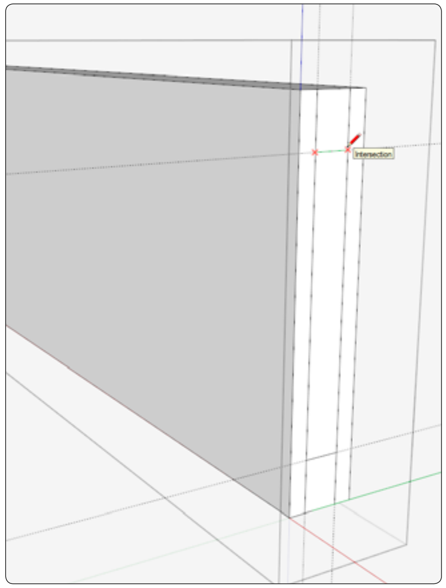


Figure 63. *Trace lines over the guidelines to size the haunch and tenon in the rail.*

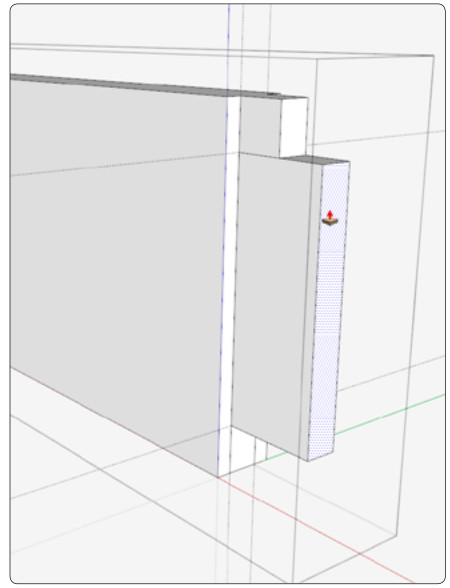


Figure 64. *Pull out the lengths of the haunch and the tenon. Also push out the groove.*

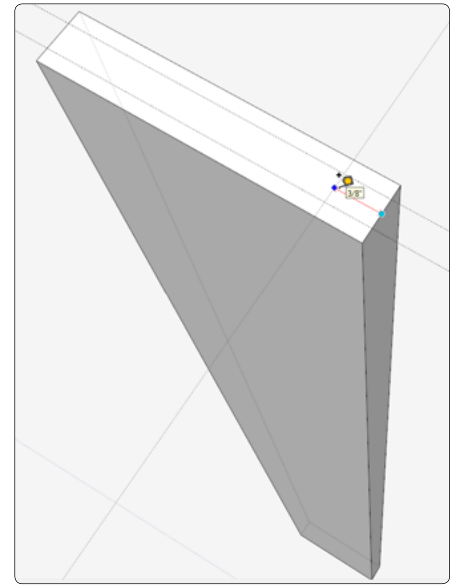


Figure 65. *Create a stile component and place guidelines for a groove in it.*

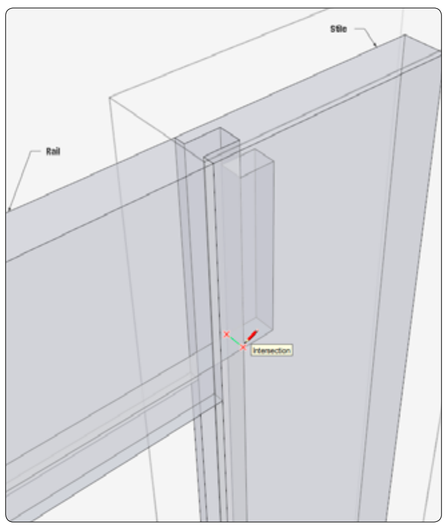


Figure 66. *Edit the stile and draw lines on the groove to outline the tenon.*

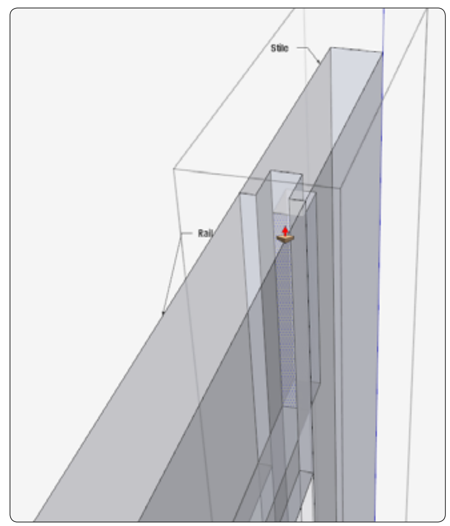


Figure 67. *Use the Push/Pull Tool to ceate the mortise in the stile.*

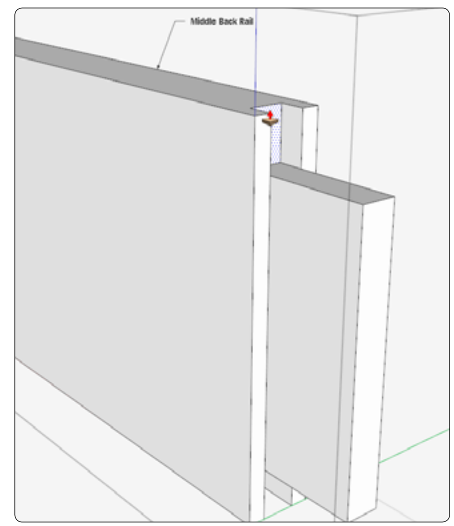


Figure 68. *Make the middle rail from a copy of the back rail. Push out the haunch to make a second groove.*

again and make it a new component named back center rail.

Use the Push/Pull Tool to push out the haunch, creating a groove on the top edge. See Figure 68.

Attach the middle rail at the midpoint of the stile and create the mortise there, following the procedure from step 30.

Copy the stile, execute a flip along command, and move it to the opposite end of the rails. This completes the construction of the back panel frame.

Step 33 To complete the back, construct the two floating panels. Figure 69 shows a panel's finished dimensions. The panels, which are not glued in place, are slightly smaller than the space between the rails and stiles. This traditional type of construction gives the panel room to expand with the seasons. The rabbet around the edge of the panel is wide enough to leave a gap between the shoulders and the rails and stiles.

Step 34 Begin drawing the panel in place between the stiles and rails. This is the fastest way to ensure that it is properly sized and positioned.

With the stiles and rails connected, draw a rectangle around the perimeter of the opening, as shown in Figure 70. Make the rectangle a component named back panel insert. Make a copy of the component and move it to fit in the other opening between the stiles and rails.

Open either one of the back panel components for editing, click on the face, and select the Offset Tool. Click the tool on an edge of the panel, begin moving the cursor toward the center of the panel, type 1⁄16, and press

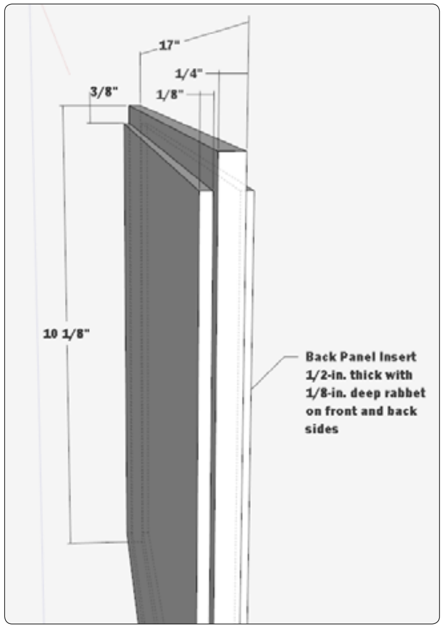


Figure 69. *The key dimensions for the back panel insert.*

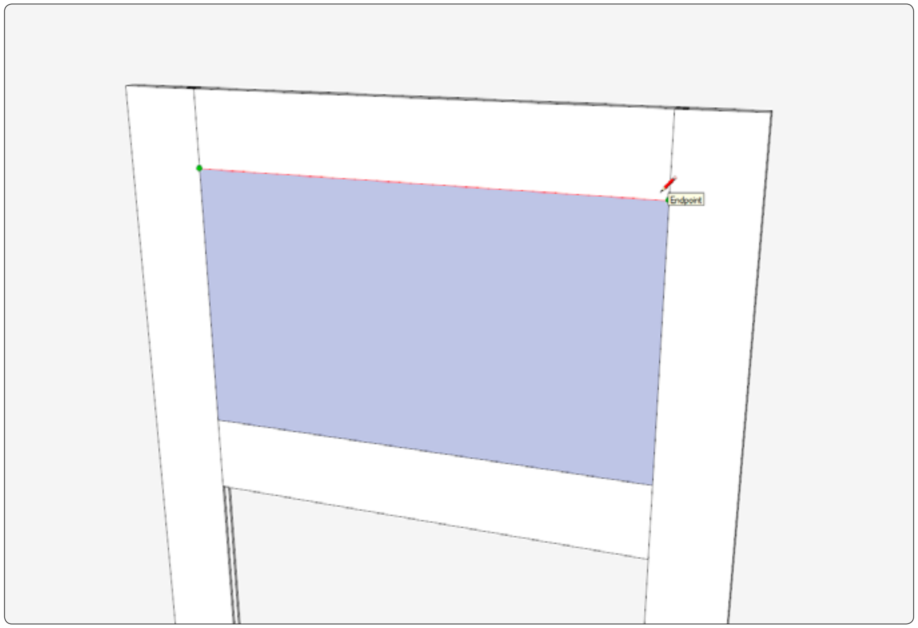


Figure 70. *Draw a rectangle around the open perimeter for the back panel insert.*

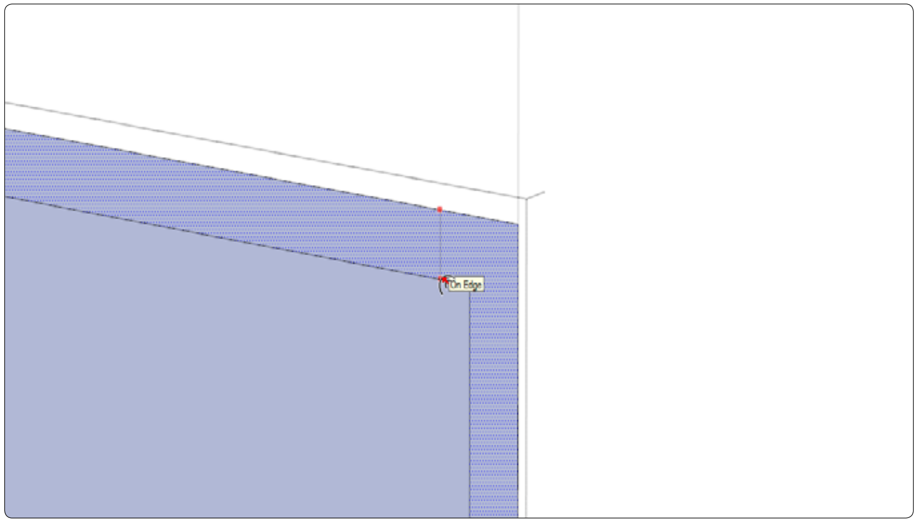


Figure 71. *Make an offset of 1⁄16 in.*

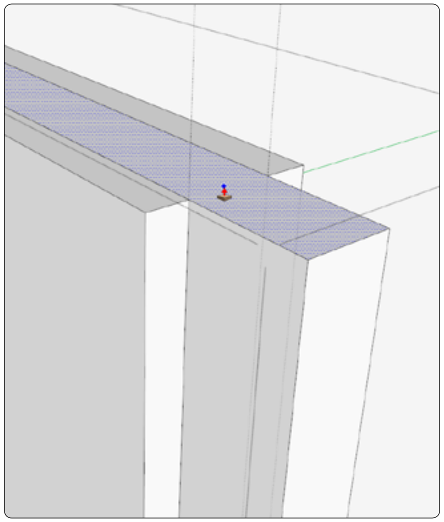


Figure 72. *Create the surrounding tongue.*

Enter. This generates lines parallel to the original edges, which you will use in the next step to make the panel slightly smaller to allow for seasonal expansion. See Figure 71.

Step 35 Create another copy of the back panel component and move it away from the assembly. Working on this copy, use the Eraser Tool to delete the original boundary of the rectangle, then use the Push/Pull Tool to give the panel a thickness of ½ in. This will also change the original panel.

Still working on the copy, use the Tape Measure Tool to place guidelines defining the ¼-in.-thick tongue around the perimeter of the panel. (By drawing a tongue on all four sides of the panel, you create the rabbet in the face of the panel.) See Figure 72.

Draw lines over the guidelines and use the Push/Pull Tool to make the tongue ⅜ in. long. Erase extraneous lines on the face of the tongues. Delete the final copy of the panel. You can inspect the spacing of the gaps by zooming in closely and choosing Back Edges from the Styles toolbar. See Figure 73.

Step 36 Move the assembled back panel close to its location in the back of the carcase. It is larger than the opening in the carcase because it fits in a 3⁄16-in.-deep groove. To position the back panel assembly properly, place guidelines 3⁄16 in. from the inside edges of the carcase opening at the rear. See Figure 74. With the Move/Copy Tool, grab one corner of the back panel and connect it to the intersection of the two guidelines.

To accommodate the French cleat, the back panel is recessed ¾ in. into the back of the carcase. With the Move/Copy Tool, click

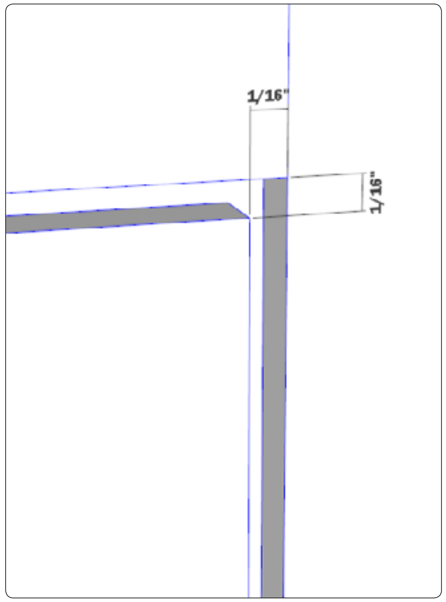


Figure 73. *Close-up of a corner, showing the 1⁄16-in. gap between panel and frame.*

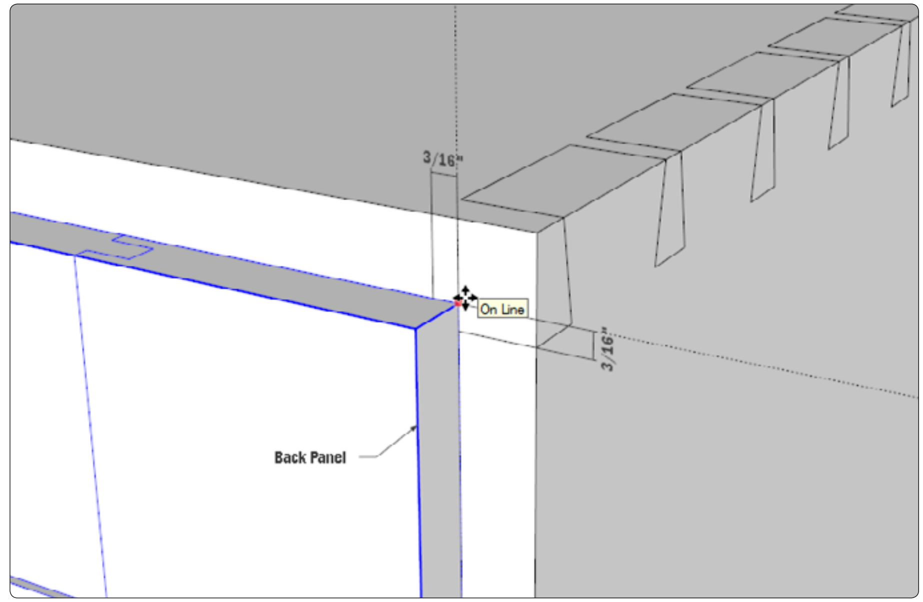


Figure 74. *Position the back panel at the rear of the carcase assembly.*

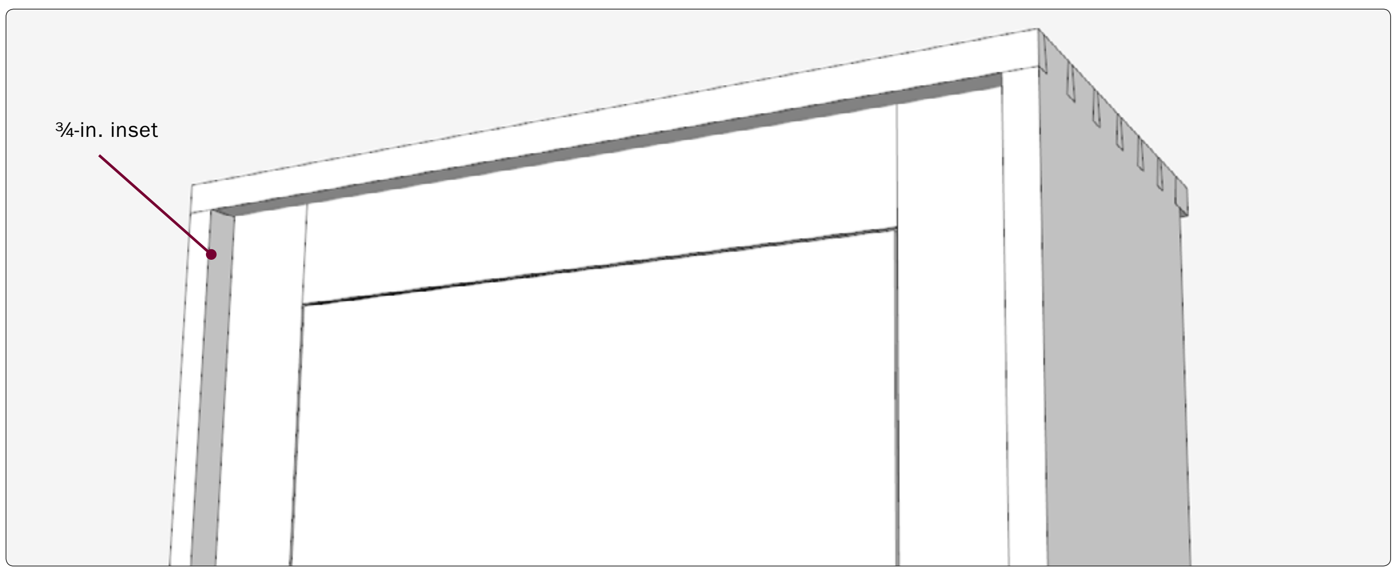


Figure 75. *Recessing the back panel into the rear of the carcase.*

on one corner of the back panel and begin moving it along the green axis. You should see it begin to move into the carcase. It is helpful to tap the left arrow key to restrain movement along the green axis. Type 1¼ in. and press Enter. This will recess the back panel properly. See Figure 75.

Step 37 Zoom in to a view of the lower back corner, as shown in Figure 76. This view will help to create the grooves in the top, side, and bottom components. Open the bottom component for editing. With the Line Tool, draw a line at the intersection of the back panel with the top face of the bottom. Do the same for one of the sides, as shown in Figure 77.

Make a copy of the bottom component and move it away from the carcase. Double-click the Tape Measure Tool on the line just placed. This creates a parallel guideline ½ in. from the first line; the groove needs to be this wide to accommodate the back panel.

Step 38 With the Line Tool, create the rectangular face of the groove, as shown in Figure 78. Take the groove all the way to the openings of the mortises. Then use the Push/Pull Tool to make the groove 3/16 in. deep. See Figure 79.

Repeat Steps 37 and 38 for the top and side components to finish the grooves for the back panel. (Remember that you only need to work on one side component; changes will appear in both.) The groove in the side needs to be stopped at the top end but can extend out the bottom end of the component. The groove in the top component can be extended out the ends.

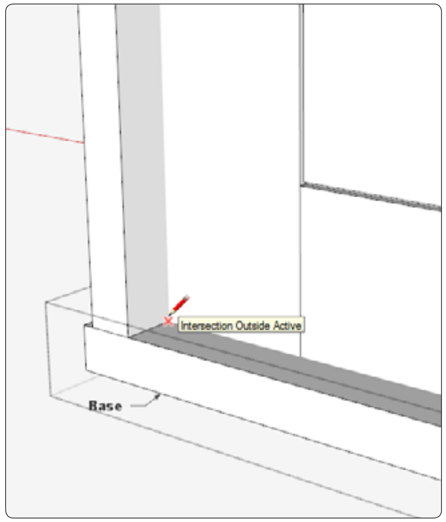


Figure 76. *Draw line at the intersection of the back panel with the top face of the bottom.*

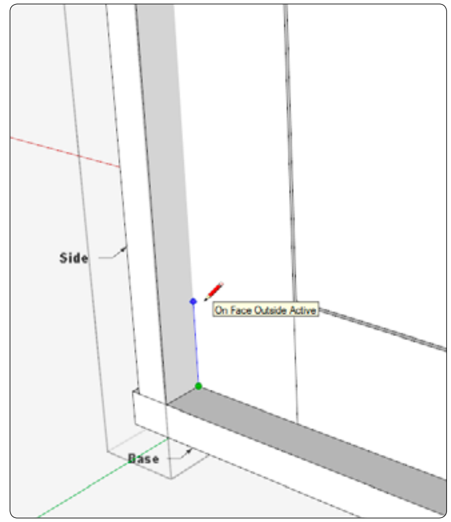


Figure 77. *Draw a line at the intersection of the back panel with the face of the side.*

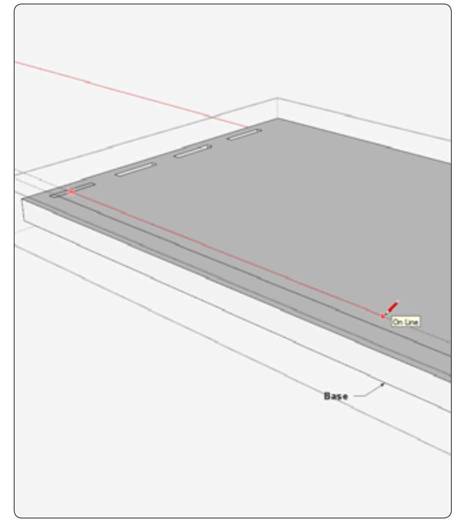


Figure 78. *On a copy of case bottom, create the ½-in.-wide rectangle for the groove.*

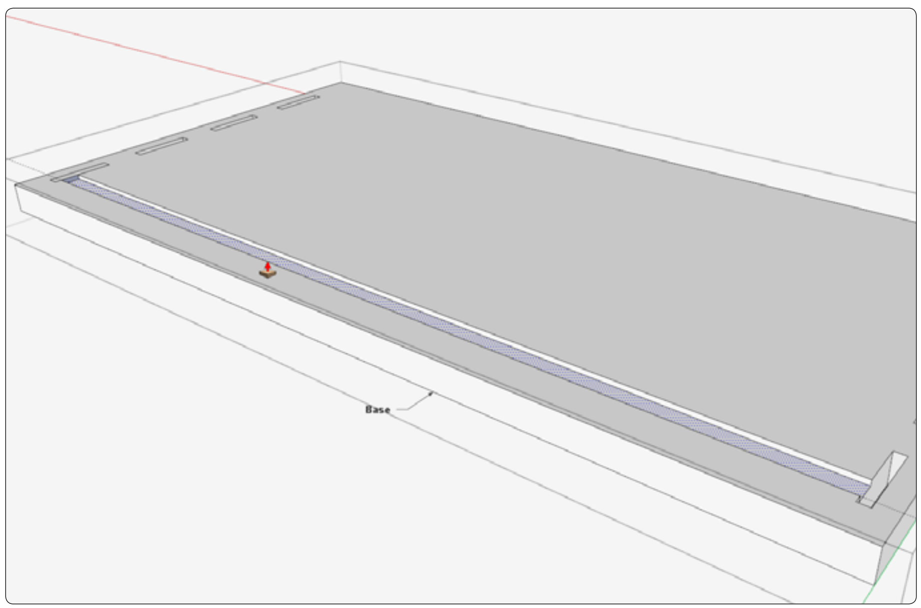


Figure 79. *Use the Push/Pull Tool to create the 3/16-in.-deep groove in the carcase bottom. The groove runs from one mortise to the other.*

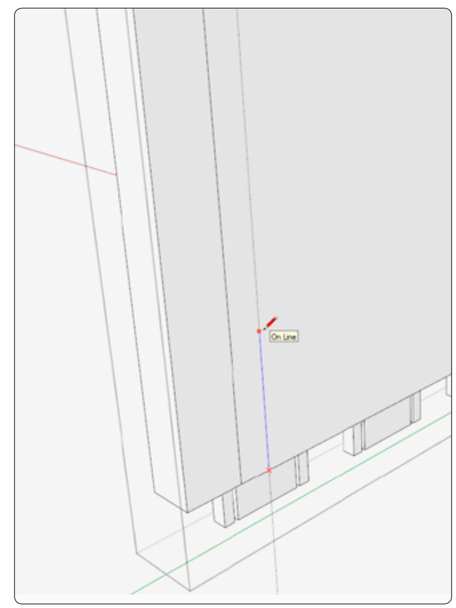


Figure 80. *Create similar grooves in the other carcase components.*

Section 5. Adding a Shelf and French Cleat

In this section we'll insert the shelf and French cleat. Because both components fit within the carcase, they must be completed at this point. In the shop, they would be cut and sized prior to glue-up.

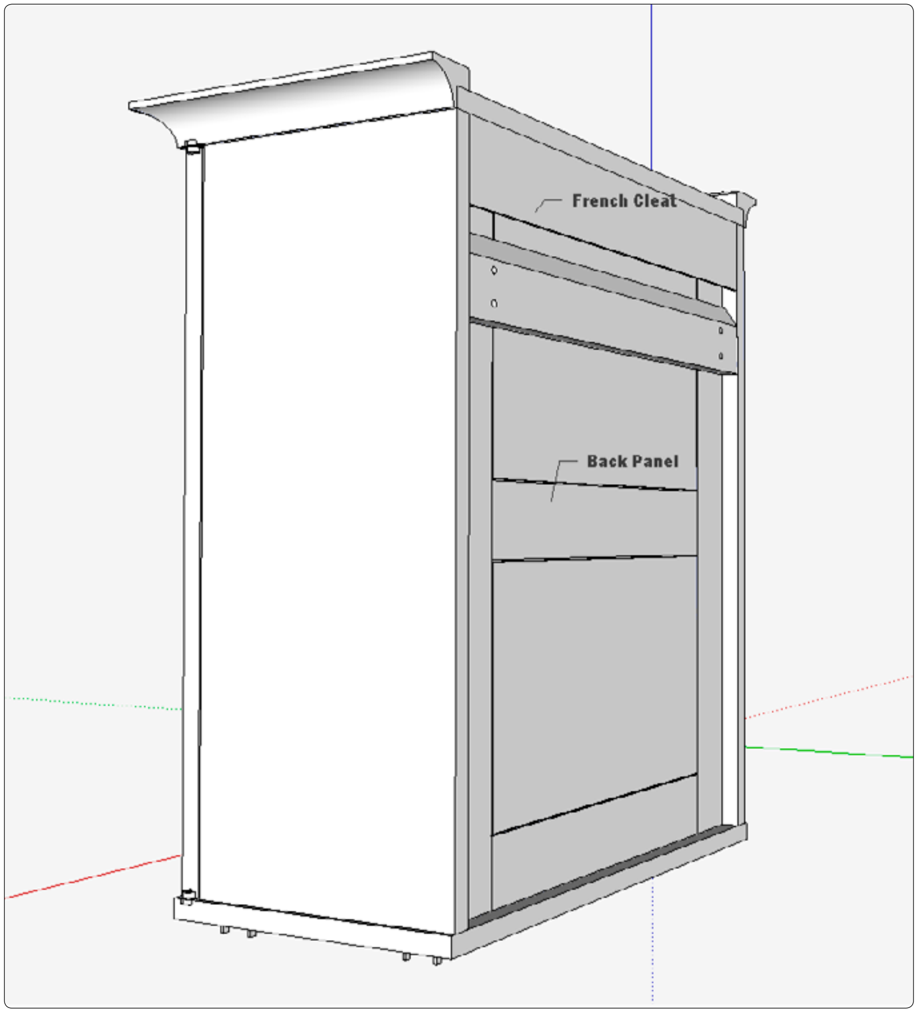


Figure 81. *Rear view of the cabinet, showing the French cleat in place.*

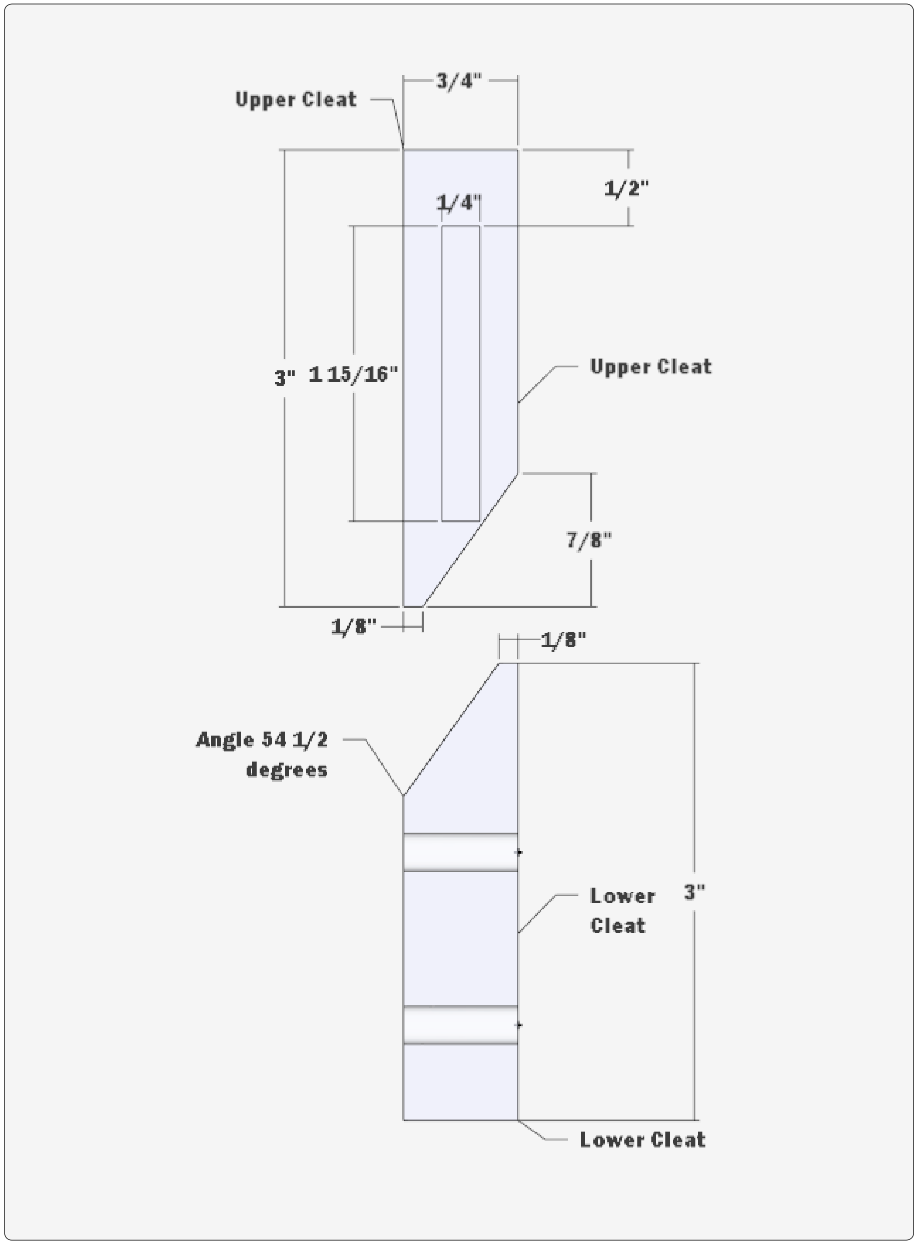


Figure 82. *End view showing the two halves of the French cleat, with measurements.*

Adding a Shelf and French Cleat

Now that the back panel is in place, you can place the shelf and its related dado in the side component. The shelf is positioned at the midpoint of the sides, creating spaces just over 13 in. high. That's ample clearance for the largest of *Fine Woodworking* magazines (what the original case was meant to hold) or many other items. Both the shelf and French cleat are drawn in position in the carcase.

Step 38 With the Tape Measure Tool, place a guideline at the midpoint of the side component. As you move the cursor up the edge of the component, following the blue axis, a red dot will appear when you have hit the midpoint. See Figure 83. Place additional guidelines to mark the width of the dado and its ends. At the rear, it ends flush with the back panel; at the front, it stops ⅛ in. from the edge of the side component. See Figure 84. Draw lines over the guidelines, then use the Push/Pull Tool to make the dado 3⁄16 in. deep, as shown in Figure 85.

Step 39 Draw a rectangle from corner to corner at the bottom of the dadoes and use the Push/Pull Tool to give the shelf its proper thickness. See Figure 86. Make the shelf a component.

Step 40 The final part of the carcase assembly is the French cleat. Figure 82 shows the end view shapes of the cleat. The upper half has ½-in.-long tenons on the ends that fit into mortises in the carcase sides.

Orbit around to the rear of the carcase. In the upper corner, draw a rectangle 3 in. wide and ¾ in. thick, the overall size of the upper

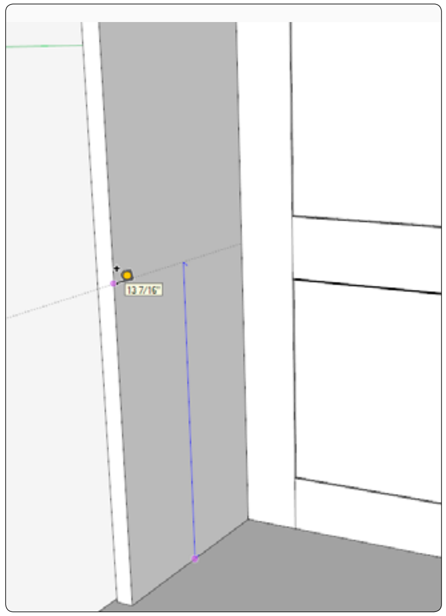


Figure 83. *Place a guideline at the midpoint of the side component.*

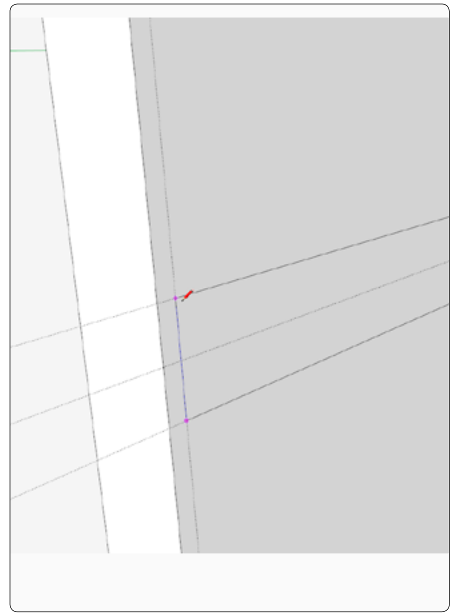


Figure 84. *Add guidelines to define the size and location of the dado in the side.*

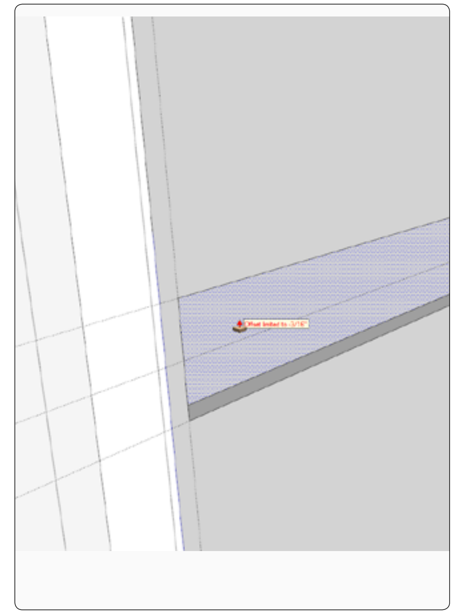


Figure 85. *Use the Push/Pull Tool to make the dado 3⁄16 in. deep.*

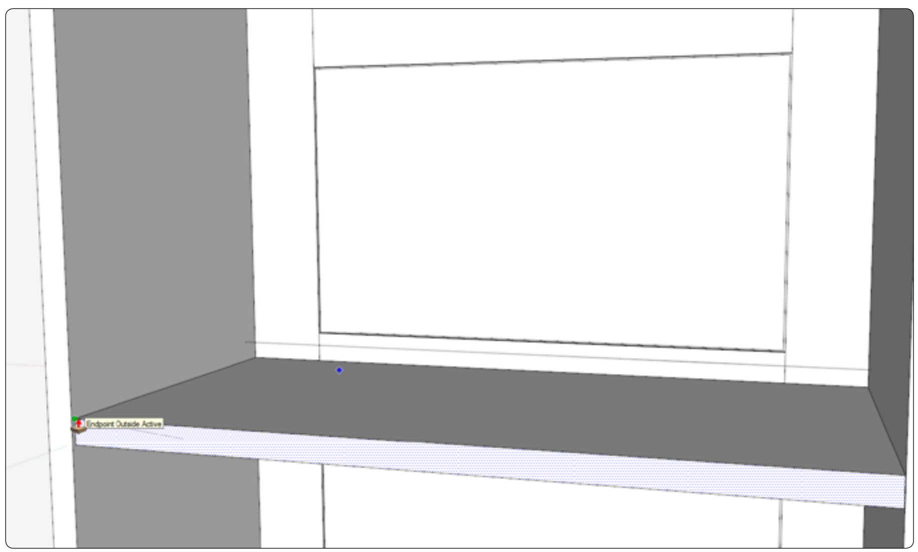


Figure 86. *Draw a rectangle within the dadoes, then give it thickness to create the shelf.*

cleat. Use the Push/Pull Tool to extend the rectangle to the opposite corner. Figure 87 shows the beginning of the push/pull movement. Make the shape a component named upper cleat.

Step 41 Make a copy of the upper cleat component and pull it away from the carcase. Working on the copy, place guidelines to define the shape and position of the tenon and the bevel. Take the measurements from Figure 82. Use the Line Tool to draw over these guides, as shown in Figure 88. Use the Push/Pull Tool to make the tenon ½ in. long and to create the bevel. See Figure 89. To finish the upper cleat component, copy the tenon to the other end, remembering to execute a flip along command. Then erase the copy of the component.

Step 42 Use the upper cleat to create the lower cleat. Copy the upper cleat. Right-click on the copy and choose Explode from the pop-up menu. Use the Select Tool to draw a box from left to right around the exploded copy. Make it a component named lower cleat. I did a flip along command twice to orient the lower cleat properly, first along the blue axis, then along the green axis. Use the Push/Pull Tool and the Eraser Tool to delete the tenons.

Step 43 Zoom close to an upper corner at the back of the carcase. Choose X-Ray from the Styles toolbar and open the side component for editing. Use the Line Tool to trace over the boundary of the tenon, then use the Push/Pull Tool to create the depth of the mortise. See Figure 91.

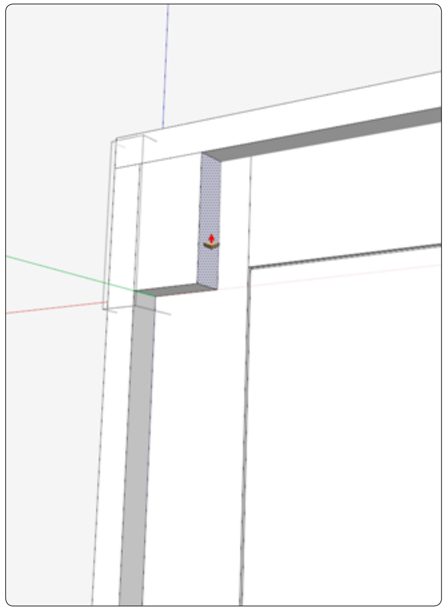


Figure 87. *Draw a rectangle and pull out the length of the upper cleat.*

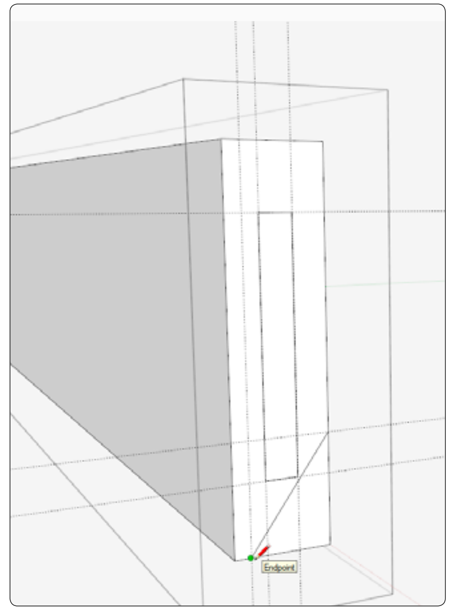


Figure 88. *Draw guides and lines to define the size and location of the tenon and bevel.*

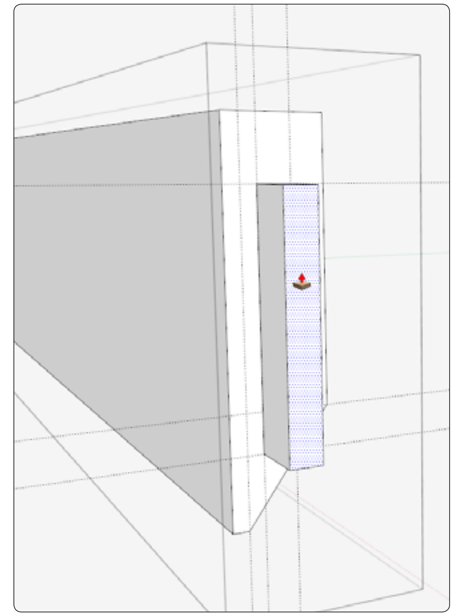


Figure 89. *Use the Push/Pull Tool to create the tenon and the bevel.*

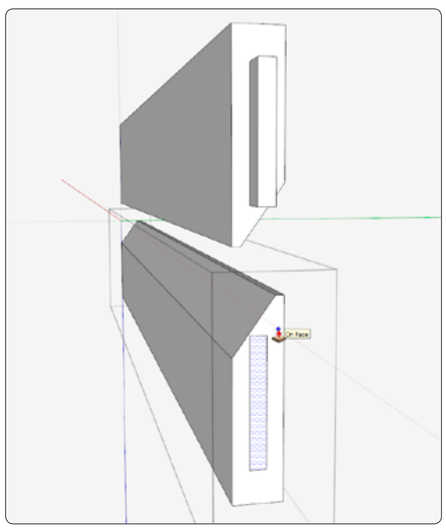


Figure 90. *Copy the upper cleat to create the lower cleat.*

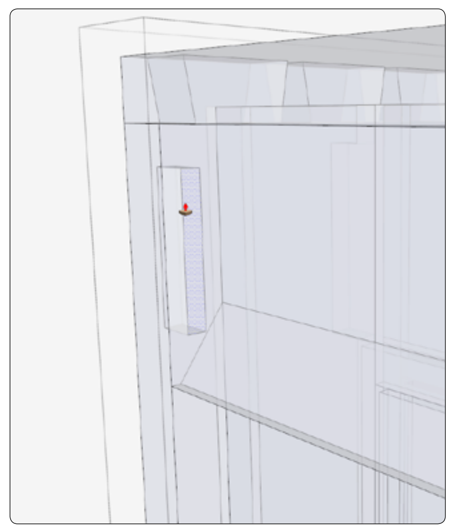


Figure 91. *Trace over the end of the tenon to create the mortise in the side component.*

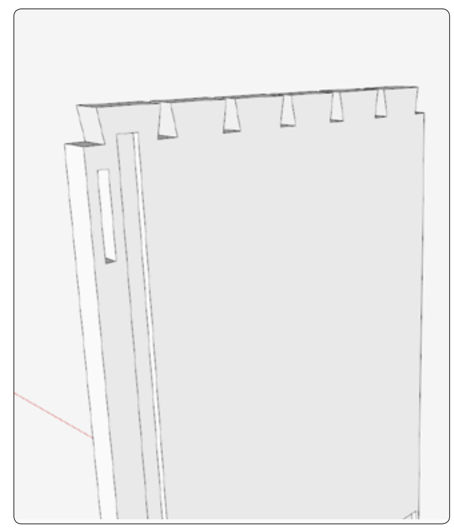


Figure 92. *A view of the inside face of the side component, with groove and mortise.*

Status Report

Figures 93 and 94 show everything that you have created for the model so far. At this stage, the carcase could be assembled and glued. However, it would be better to make the slots for the door hinges in the top and bottom before permanently assembling the carcase.

Creating properly sized and positioned hinge slots requires detailed information about the actual hinges to be used. I recommend ordering the hinges well before starting construction in the shop. That way, you can take all the measurements you need to render the slots in the SketchUp model directly from the hinges.

Both in SketchUp and in the shop, it's useful to complete the doors before cutting the hinge slots in the carcase. So, before making this cabinet in the shop, I would hold off on gluing up the carcase until I have finished the doors and have the hardware in hand. Gochnour recommends the same strategy.

Gochnour's *Fine Woodworking* article does not say what he used for door latches, but I suspect that he used bullet catches. But, of course, you can choose from dozens of ready-made latches or even design your own. Again, I would want the latch hardware on hand before gluing up the carcase.

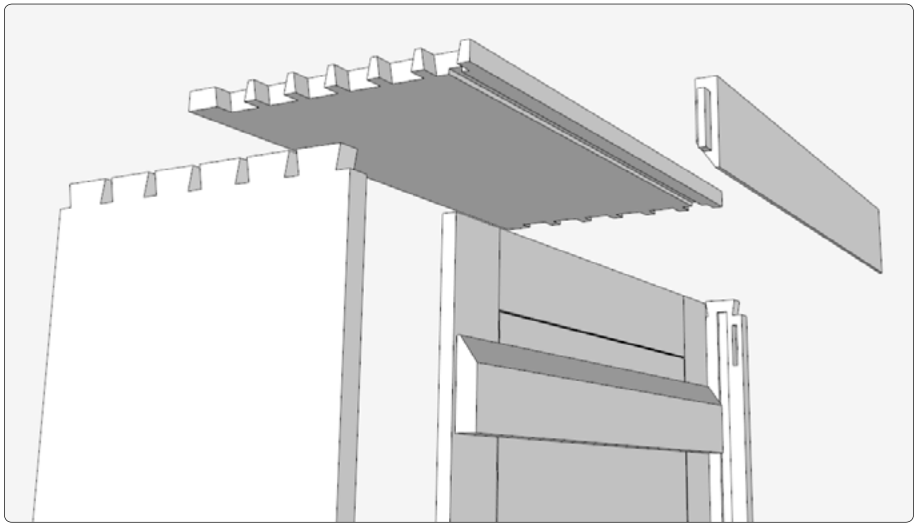


Figure 93. *A rear view of the exploded carcase.*

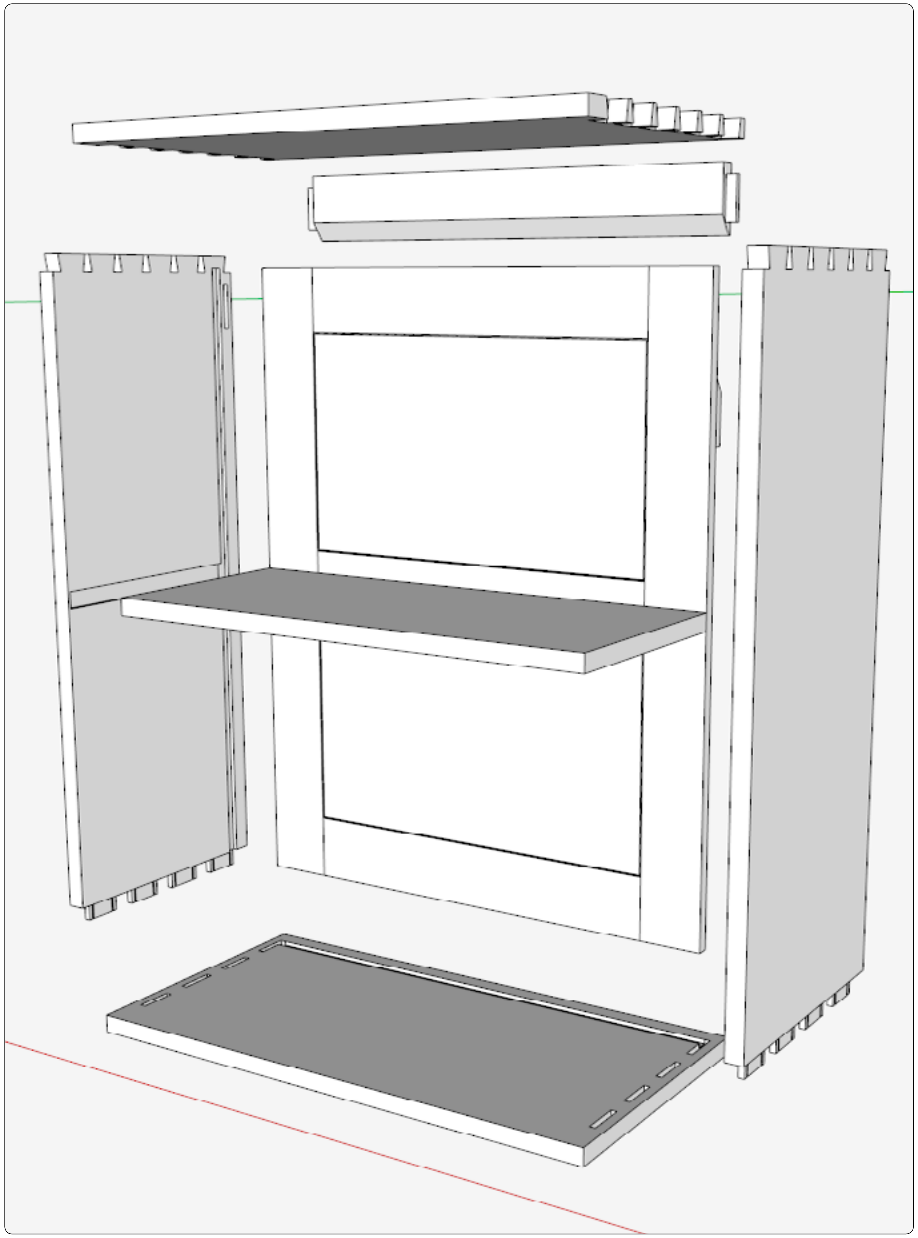


Figure 94. *An exploded view showing the components created so far.*

Section 6. Extruding the Cove Molding

In this section you'll create the cove molding. This requires another very helpful tool in SketchUp—the Follow Me Tool. As explained in Chapter 1, you use this tool when making turnings or creating shapes that move along a path. In this case, the path is the perimeter of the carcase top.

Creating the cove shape will also introduce you to the Arc Tool. It makes easy work of drawing segments of a circle.

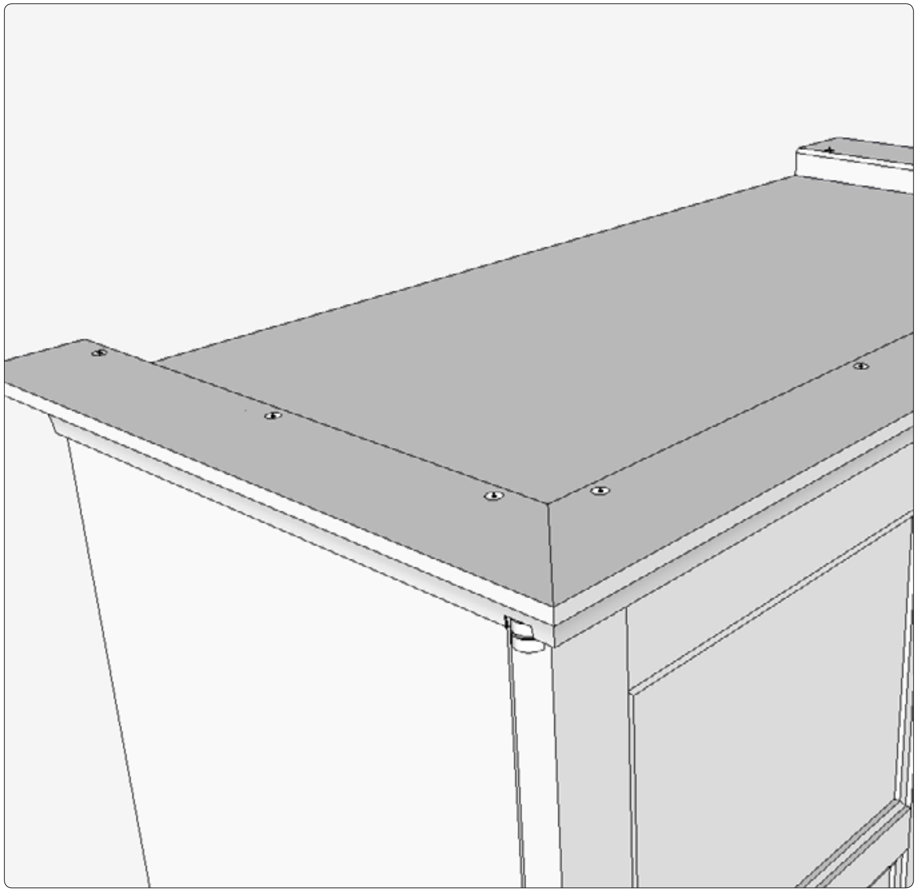


Figure 95. *The cove molding is fastened to the finished carcase with wood screws driven down from the top.*

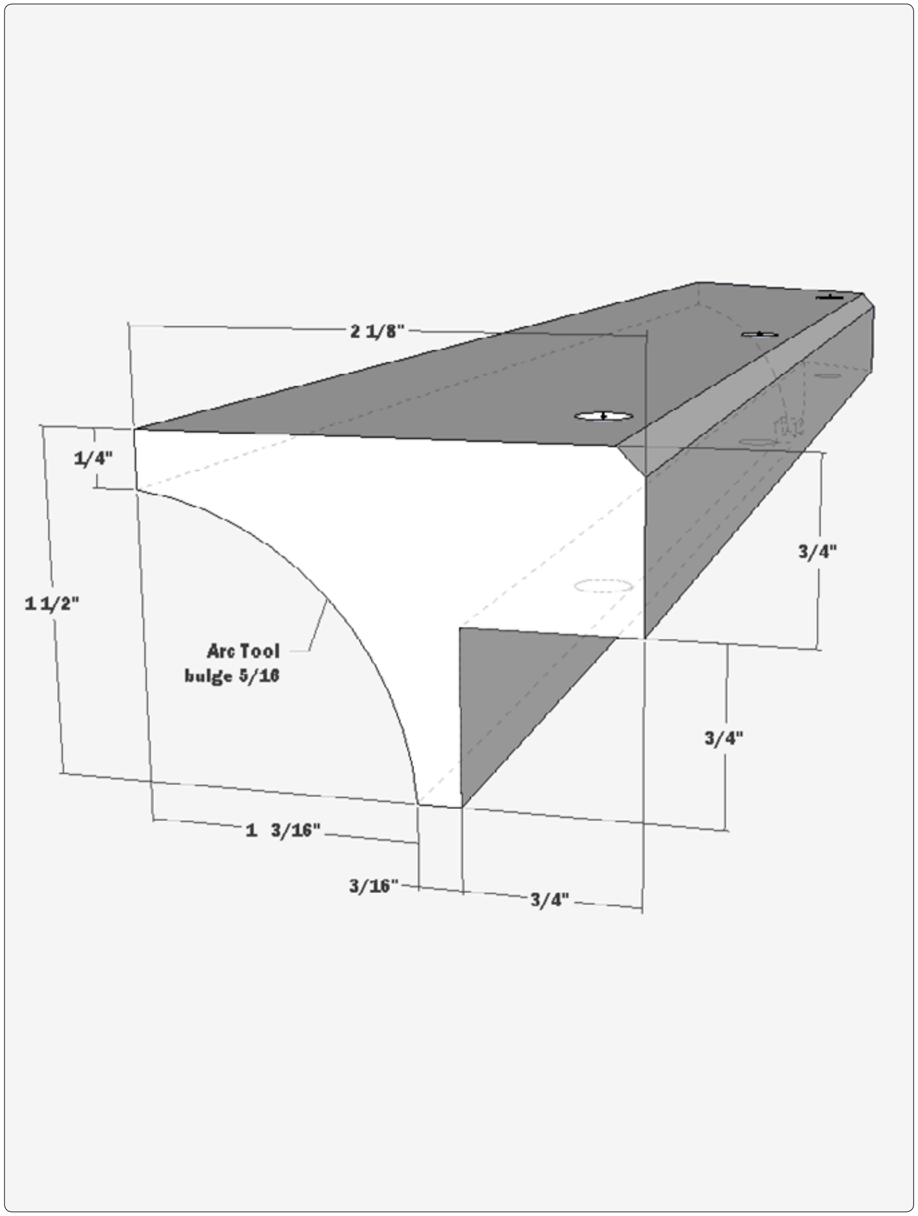
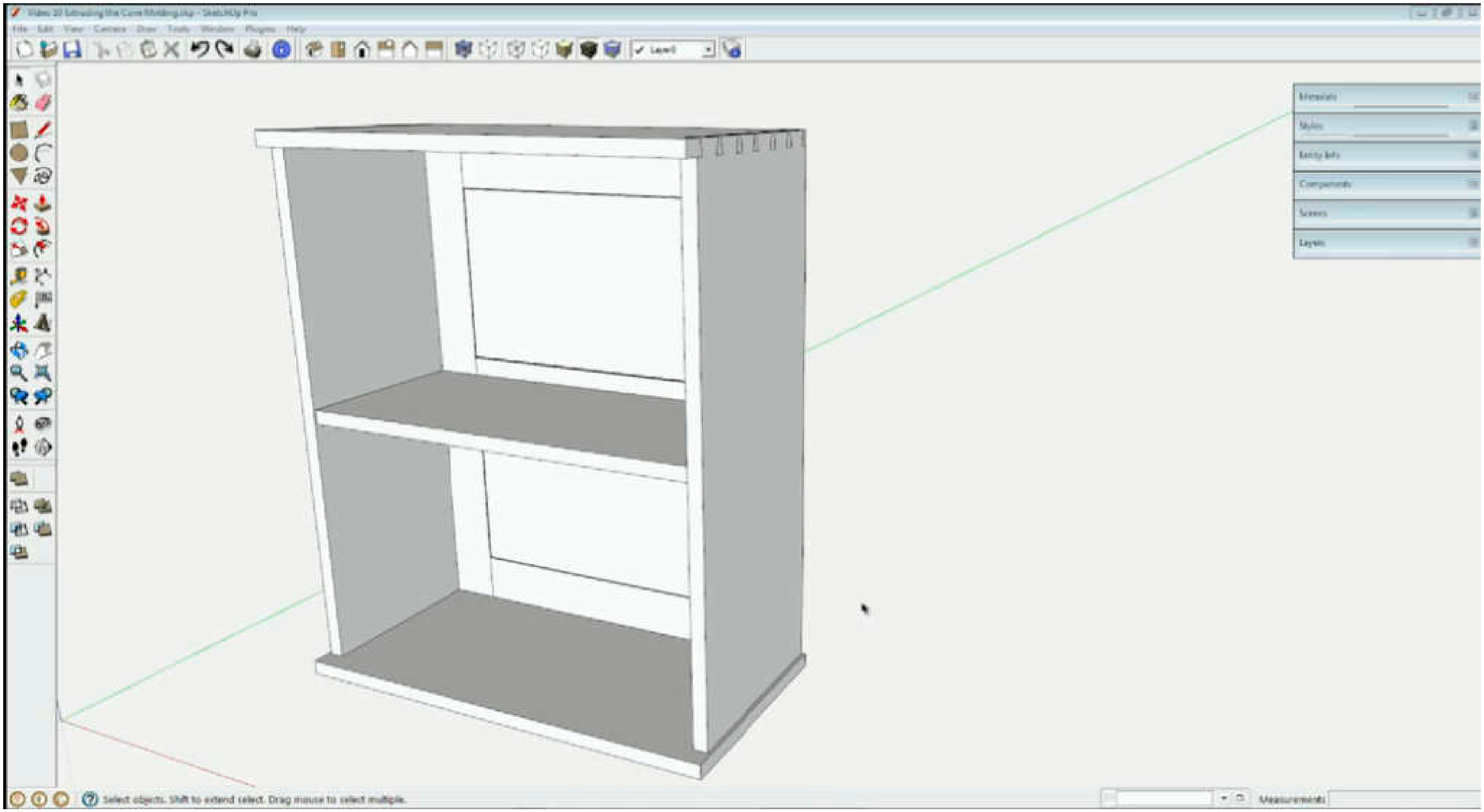


Figure 96. *The profile for the cove molding at the top of the cabinet, with all its necessary dimensions.*

Video Tutorial: Extruding the Cove Molding

This video shows how to use the Follow Me Tool to extrude the cove molding around the carcase top. Once the molding is created, it will be mitered at the corners.



Extruding the Cove Molding

All you need to create the cove molding is a profile shape and a path. The dimensioned profile shape is shown in Figure 96. Use it to create a flat profile.

Step 44 Begin by making a rectangular face 2⅛ in. wide by 1½ in. high. Draw it on the red-blue axis to make it easy to place in the rest of the model.

Use the Tape Measure Tool to place guidelines marking the rabbet and chamfer on the back and the ends of the cove, following the dimensions in Figure 96. Choose the Arc Tool and click on the endpoints of the arc, as shown in Figure 97. Move the cursor diagonally from top to bottom to display the arc. Type 5⁄16 and press Enter.

You always want to be sure an arc is on the proper plane, not hanging somewhere out in 3D space. Be sure the small window next to the Arc Tool cursor reads "on face" as you create the arc.

Step 45 Use the Line Tool to trace out the rest of the profile shape. Delete the guidelines and waste areas, leaving a shape like the one shown in Figure 98. Make it a component called cove molding.

Position the profile on the upper rear corner of the carcase, as shown in Figure 99. Then draw a path for the Follow Me Tool to use when extruding the molding. In this case, the path follows the upper edge of the sides and the front edge. Use the Line Tool to create this path exactly above the carcase. Placing vertical guidelines at the corners will simplify the task of drawing the path. See Figure 99.

With the Select Tool, highlight the three

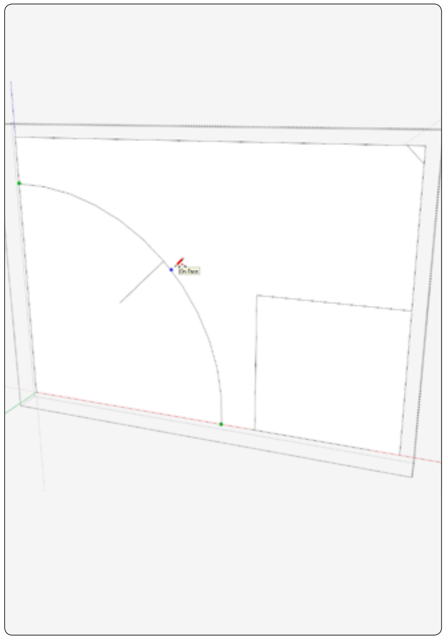


Figure 97. *Place an arc with a 5⁄16-in. bulge.*

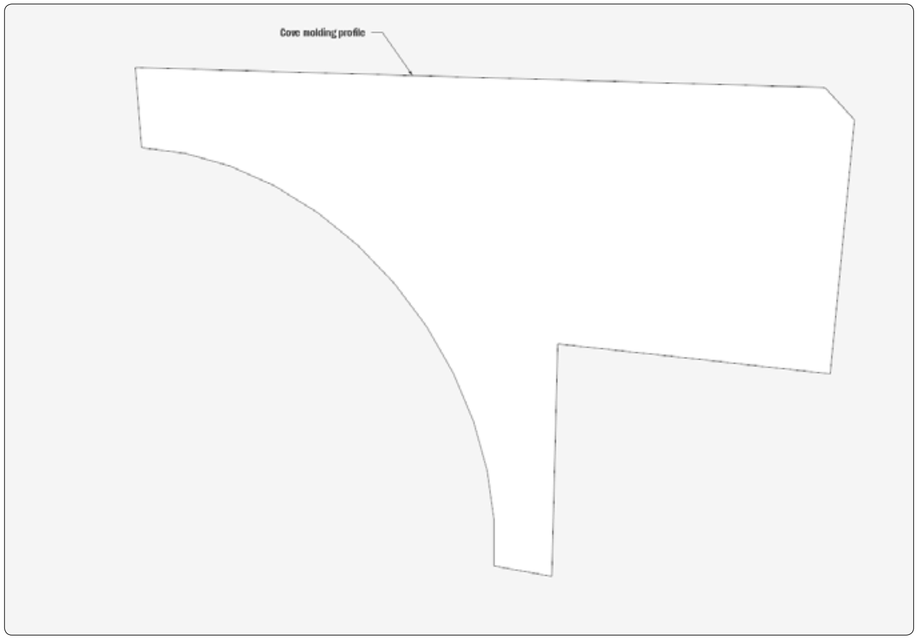


Figure 98. *The final shaped profile for the cove molding.*

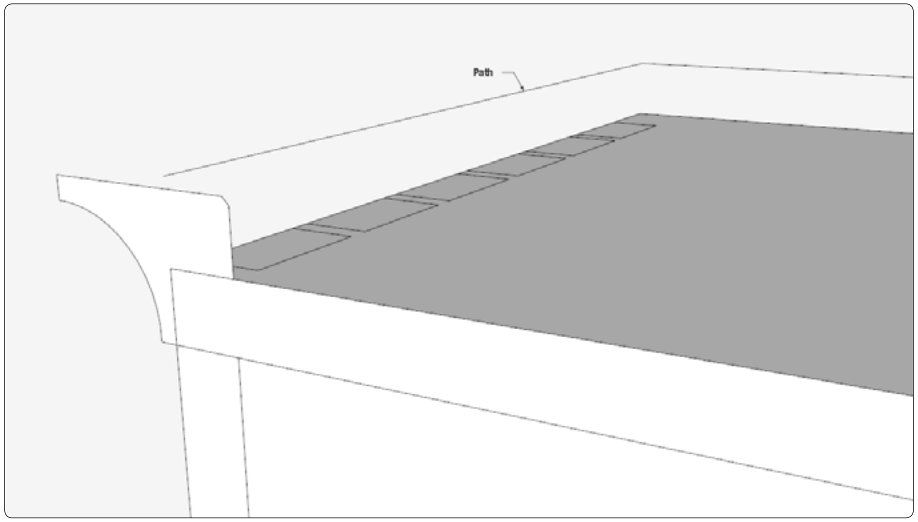


Figure 99. *Position the profile on the back edge of the carcase Top. With the Line Tool, draw a path for the Follow Me Tool.*

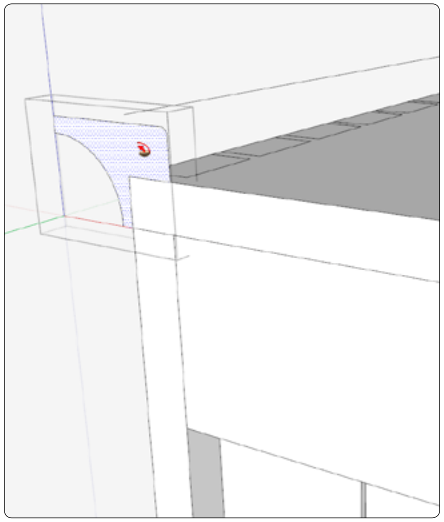


Figure 100. *Select the path, then choose the Follow Me Tool.*

segments of the path, then choose the Follow Me Tool and move the cursor over the profile. Right-click the mouse and choose Edit Component from the pop-up menu. Click the mouse on the profile. Immediately, the full length of the cove molding will appear along the top of the carcase. Figure 101 shows the fully extruded cove molding.

In the shop, the molding would consist of three individual pieces mitered at the corners. I don't see any advantage to dividing the molding in SketchUp. Typically, I just add lines at the corners to correctly indicate the joint. However, those lines create a face, which you can see in Figure 102. If you wish, you can take advantage of that to separate the molding.

Step 46 The cove molding is fastened to the carcase with wood screws driven from the top of the molding into the carcase top. I also glue the front molding piece to the carcase, but glue only the first couple of inches of the side molding pieces. It's good shop practice to use oversized shank holes in the cove molding to accommodate any seasonal movement of the carcase top.

I typically show all wood screw shank holes in my SketchUp models, which helps in the shop. See Figure 103.

To draw countersunk holes, open the cove molding for editing and use the Circle Tool to draw a circle for the shank hole. Use the Offset Tool to make a second circle outside the first. Use the Push/Pull Tool to push the shank hole through the molding. Then, click on the rim of the shank hole with the Move/Copy Tool and push the rim down slightly, along the blue axis. Stop when the countersink shape looks about right.

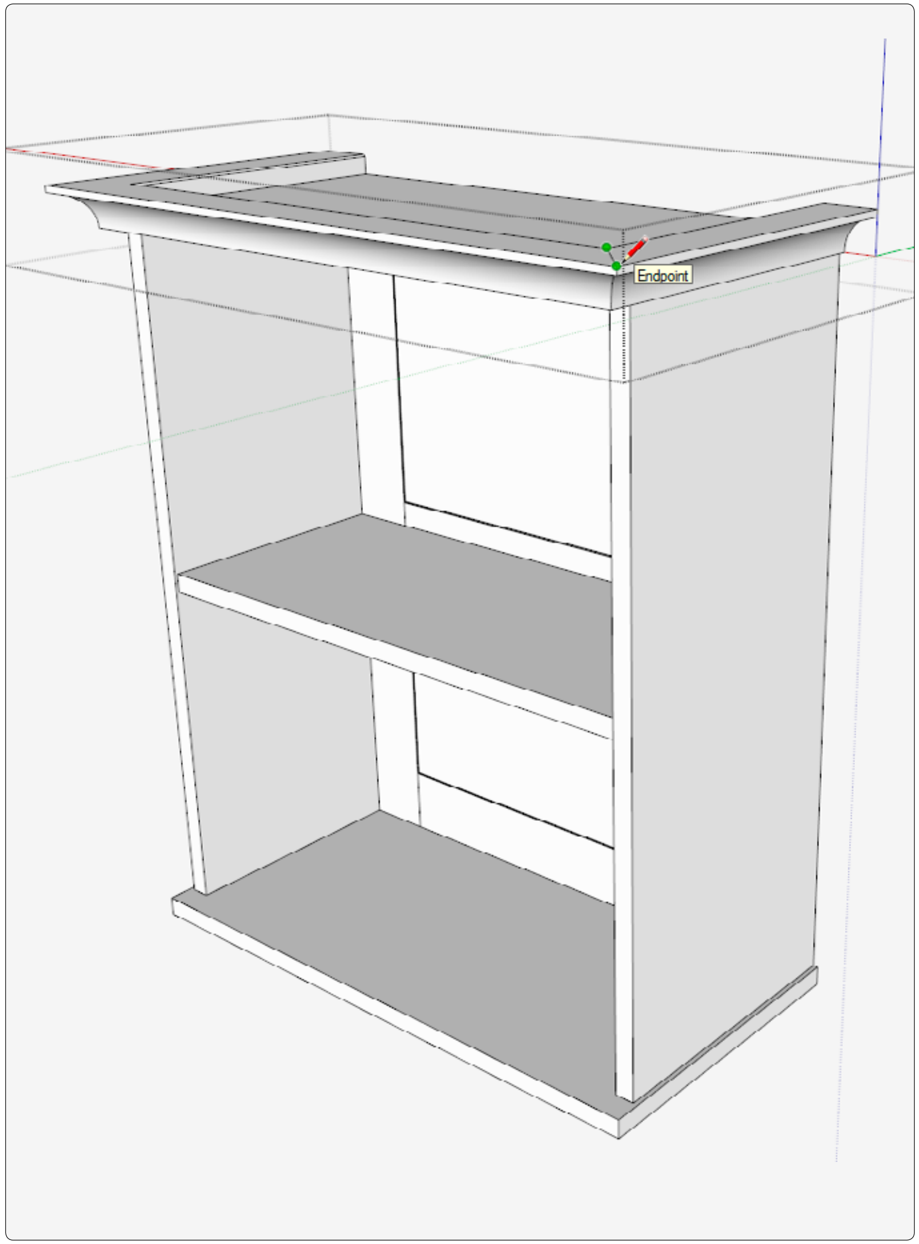


Figure 101. *The completed carcase with the cove molding in place.*

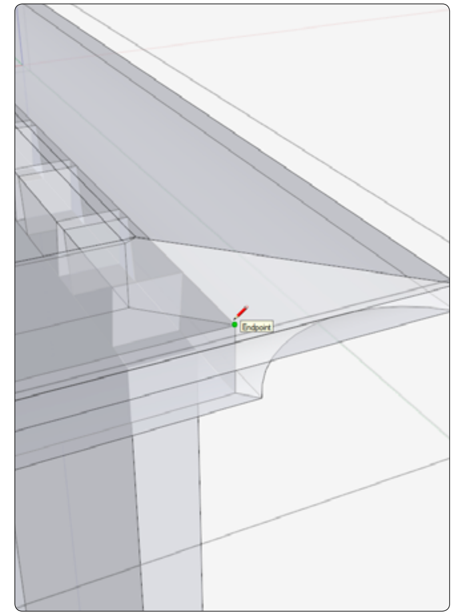


Figure 102. *Create a face at the miter joints.*

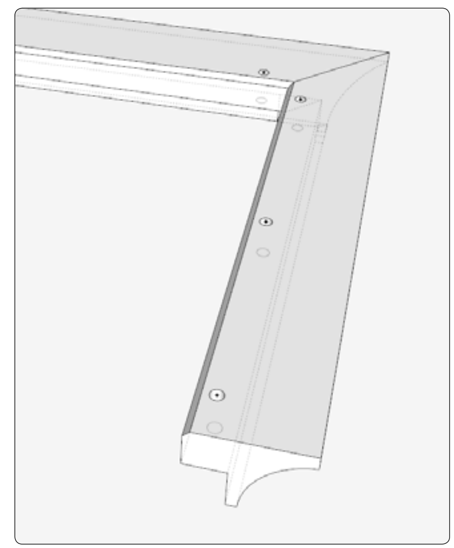


Figure 103. *Place screw shank holes.*

Section 7. Building the Paneled Doors

In this section you'll create the paneled doors. This will be done in much the same way as you constructed the back panel. There are a few differences. The doors have a thin, flat floating panel, unlike the thicker rabbeted panels on the back. The doors also have a mitered rabbet along the inside edge of the rails and stiles. In the shop, you would use a chisel to pare away the waste and make the mitered joint. In SketchUp, you will use the Protractor Tool and the Eraser Tool.

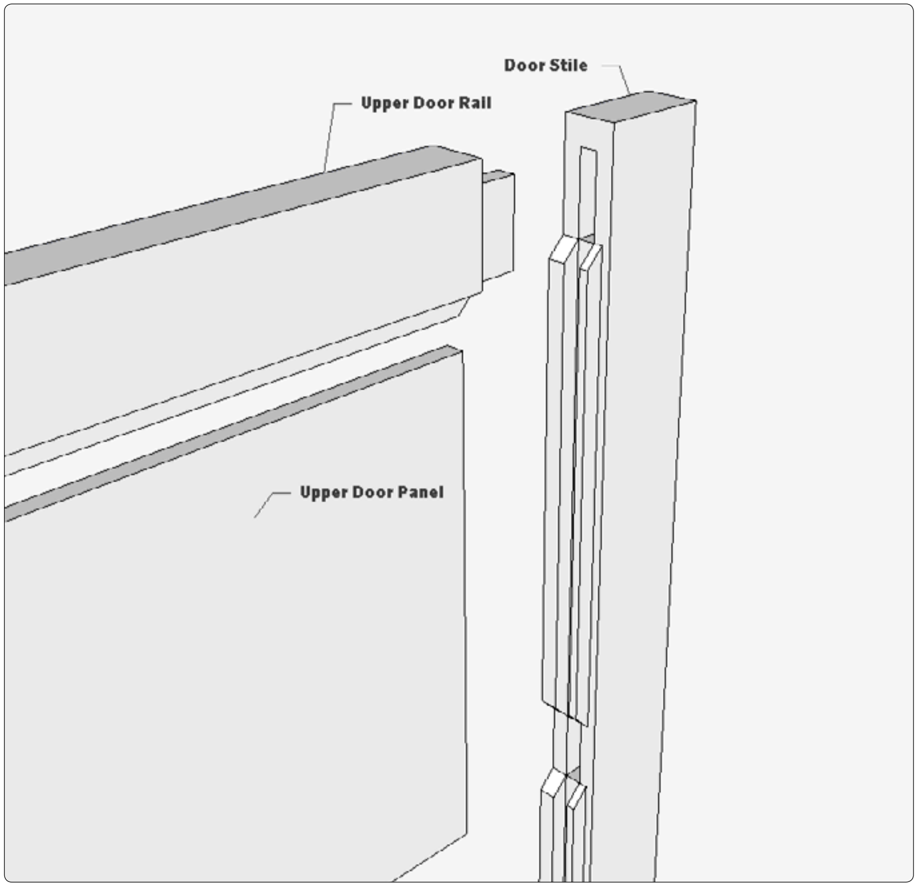


Figure 104. *The upper corner of the door, disassembled.*

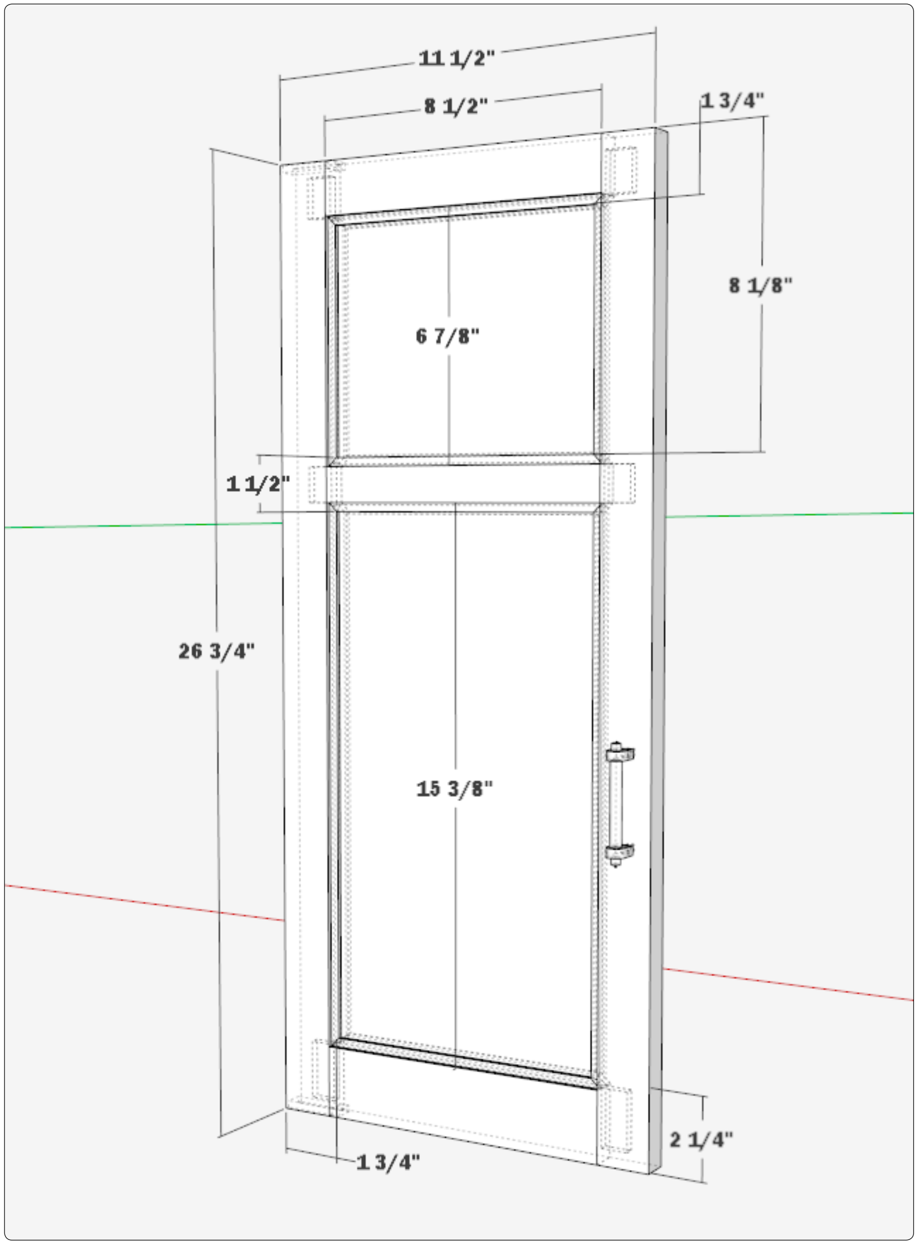


Figure 105. *The assembled door, with its key dimensions.*

Building the Paneled Doors

Gochnour has chosen a very traditional type of door construction—stiles, rails, floating panels, mortise-and-tenon joints, and a mitered rabbet on the inside edge next to the panels.

The doors fit between the carcase top and bottom with a 1⁄16-in. gap at either end. The dimension shown in Figure 105 will leave that gap if the carcase is made to the exact designed value. However, it is far better to size the doors according to the actual dimension of the carcase.

Traditional doors like these are often made with through tenons, which are pinned for added strength. As you can see, the doors on this cabinet use simpler short tenons. However, you can easily modify the plan.

Step 47 Begin by drawing a rectangle on the red-blue axes the overall size of one door: 11½ by 26¾ in. Place guidelines to outline the sizes of the stiles and rails. Add guidelines to mark the rabbet on the inside edges of the frame pieces. See Figure 108. Trace over the guidelines with the Line Tool.

Step 48 With the Select Tool, draw a left-to-right selection box around the top rail, which highlights it in blue. Right-click on the selection and choose make component from the pop-up menu. Name the component upper door rail. See Figures 109 and 110. Be sure to check the box that says, "Replace Selection with Component." Follow the same procedure to create the remaining rails.

Step 49 Make a copy of the upper door rail component and move it away from the assembly. Use the Push/Pull Tool to give it a

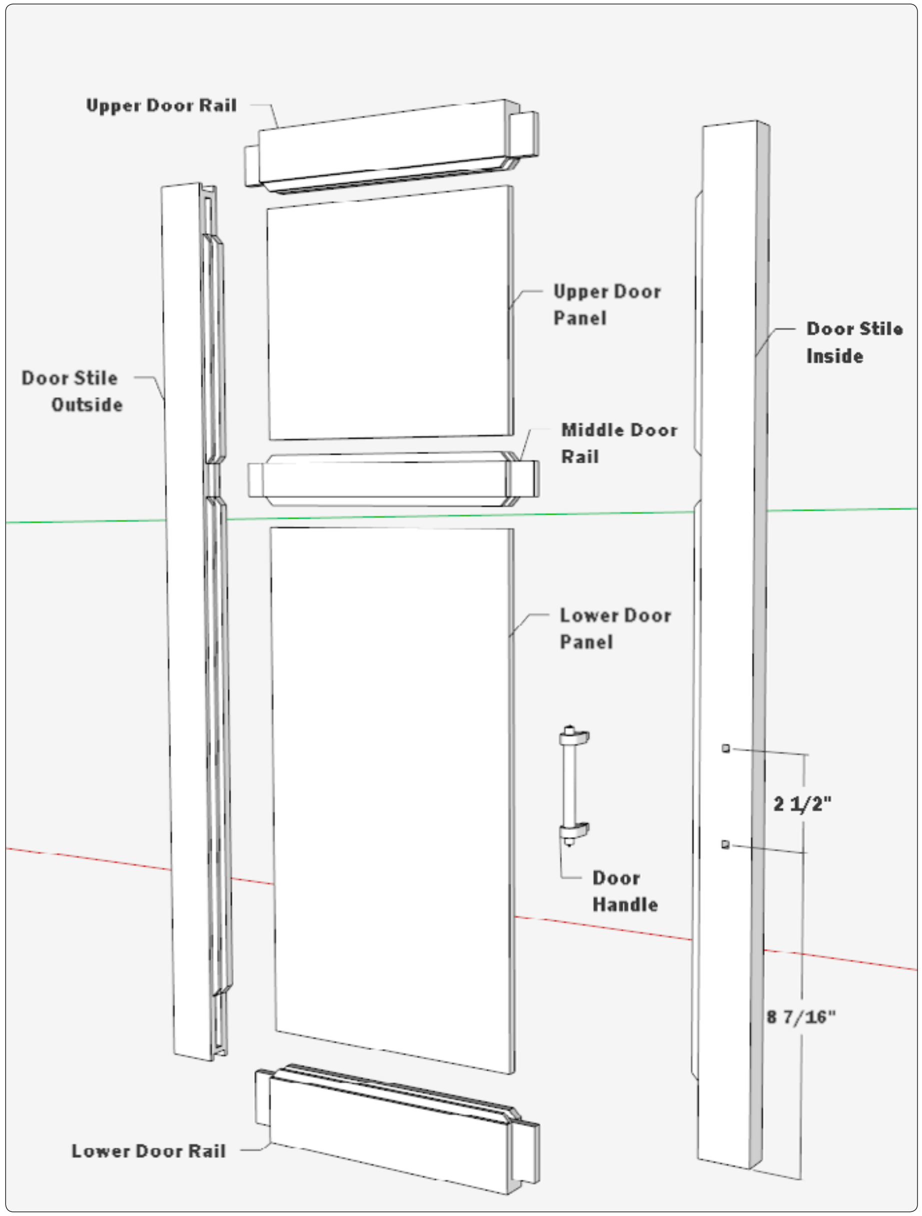


Figure 106. An exploded view of the door, showing the position of the pull and a cutout for the hinge at the ends of the outer stile.

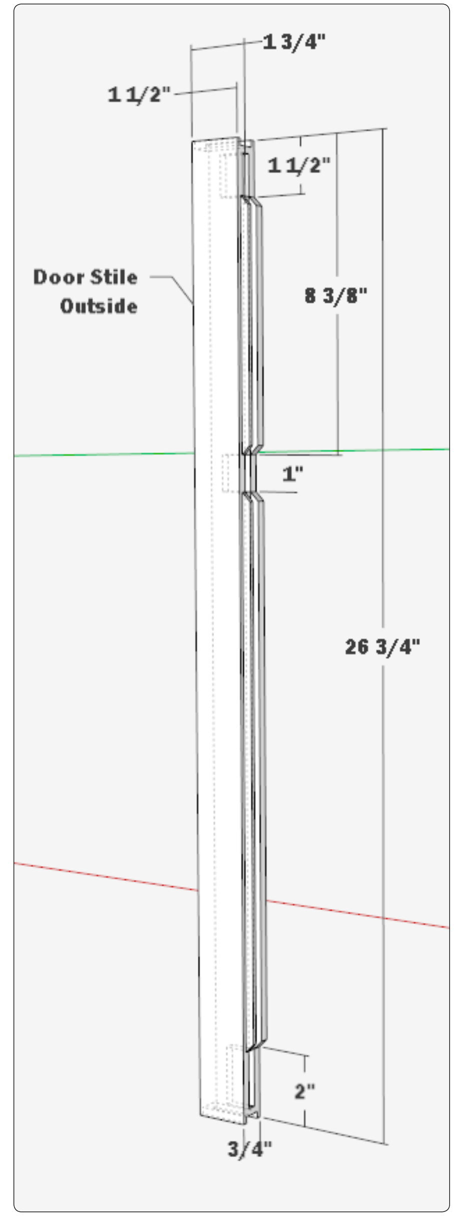


Figure 107. Dimensions for the door stile.

thickness of ¾ in. Also, draw a horizontal line ¼ in. from the lower edge of the front face, then use the Push/Pull Tool to create the ⅛-in.-deep rabbet. See Figure 111.

Step 50 Zoom in to one end of the rail and place guidelines for the position of the groove and the tenon. Use the Push/Pull

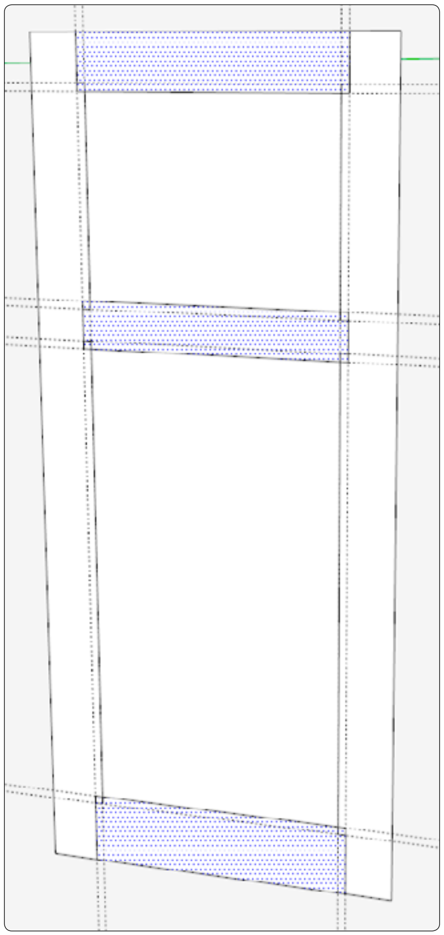


Figure 108. *Draw a rectangle the size of the door and outline the pieces.*

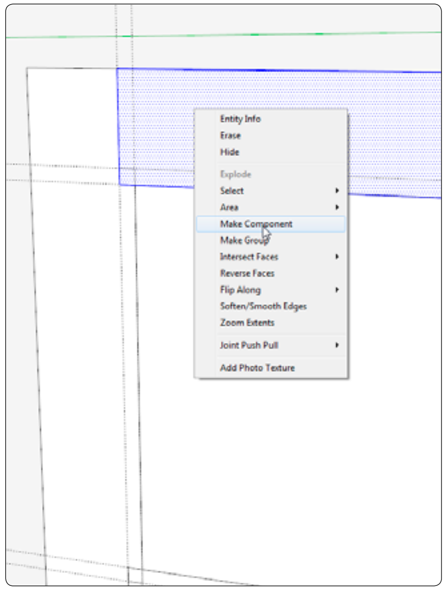


Figure 109. *Select the top rail and right-click on the selection.*

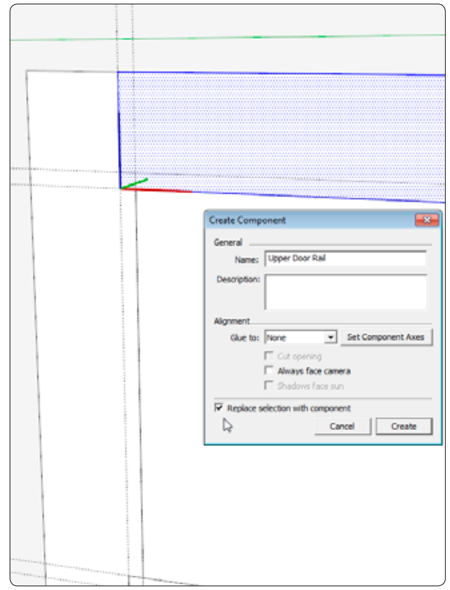


Figure 110. *Make a component called upper door rail.*

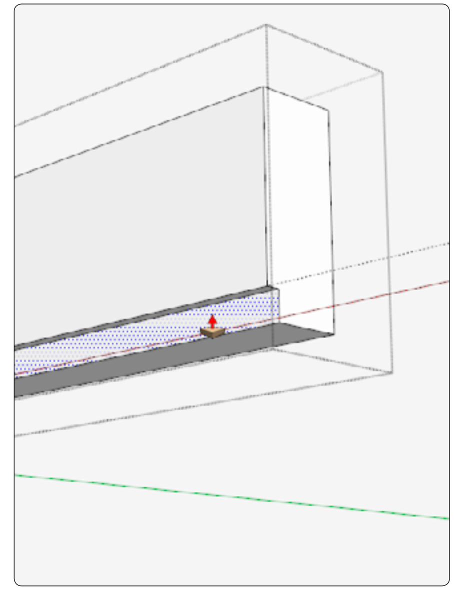


Figure 111. *On a copy of the upper door rail, give it thickness and the rabbet.*

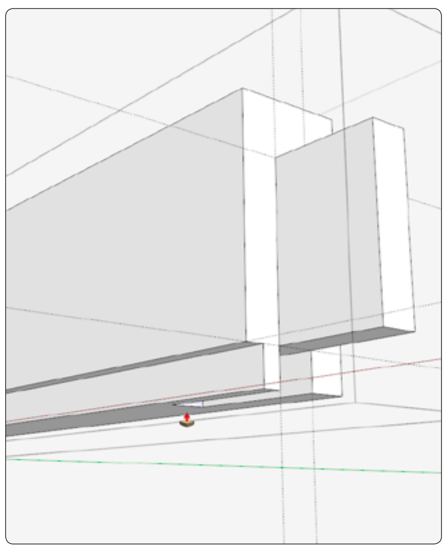


Figure 112. *Pull out the tenon and push out the groove.*

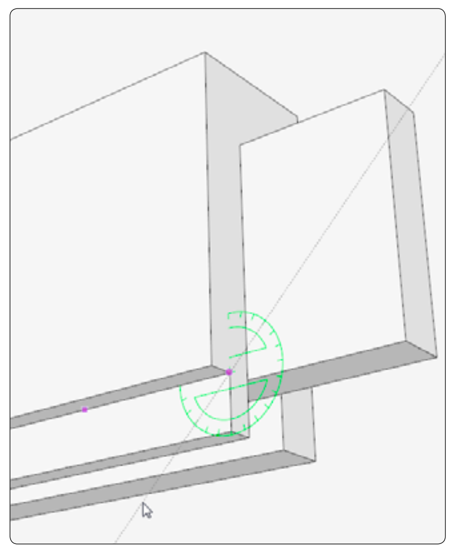


Figure 113. *Use the Protractor Tool to create a 45-degree guideline.*

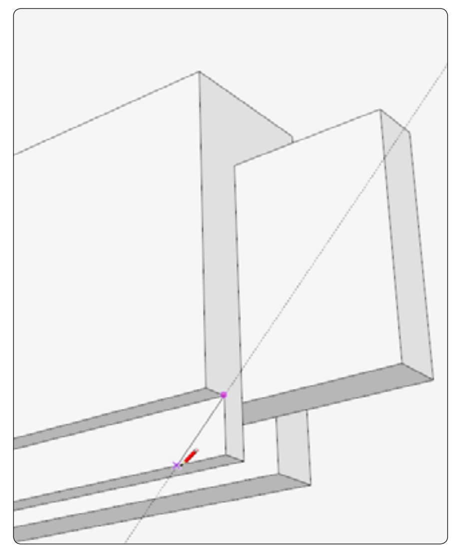


Figure 114. *Draw a line over the guideline.*

Tool to create a tenon ¾ in. long and to push out the groove. See Figure 112.

Step 51 Traditional paneled doors have a small bead shape on the inner border of the stiles and rails. In this case, Gochnour has used a flat rabbeted shape that is mitered at the corners.

As shown in Figure 113, use the Protractor Tool to place a 45-degree guideline at the end of the rabbet. The cursor should be green, indicating that the protractor will rotate around the green axis. Click at the corner of the rabbet to anchor the Protractor Tool, begin moving the mouse clockwise, type 45, and press Enter.

Trace a line over the guideline, then push

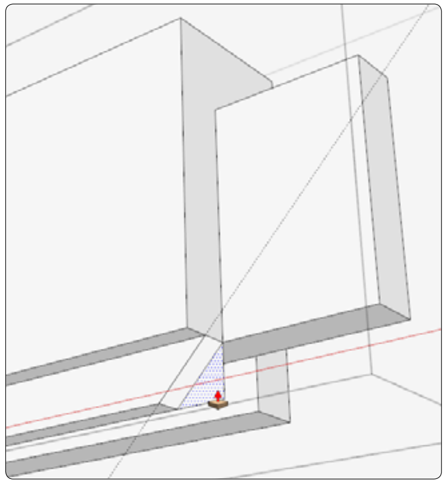


Figure 115. *Push out the waste with the Push/Pull Tool.*

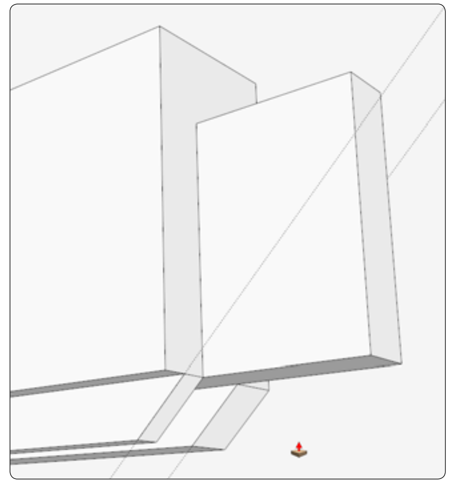


Figure 116. *Repeat the process to make a miter on the back side of the rail.*

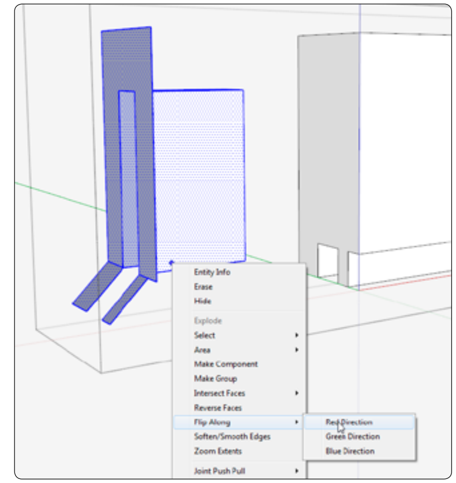


Figure 117. *Move a copy of the tenon to the opposite end, then flip along the red axis.*

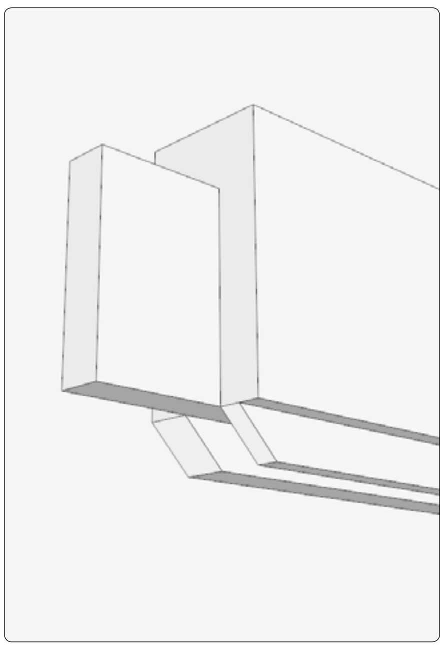


Figure 118. *Completed joinery on the upper door rail.*

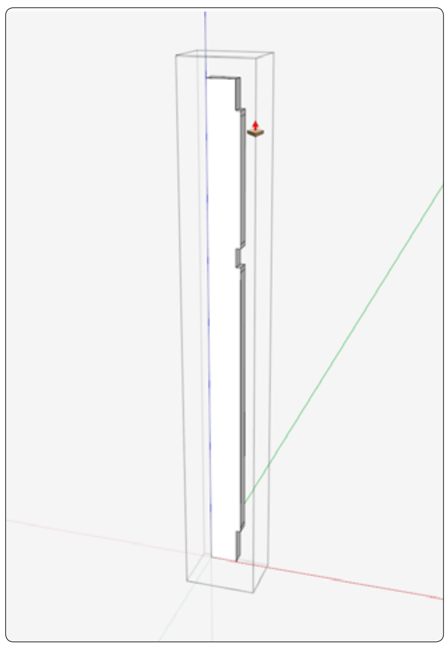


Figure 119. *Draw the stile shape and give it a thickness of ¾ in.*

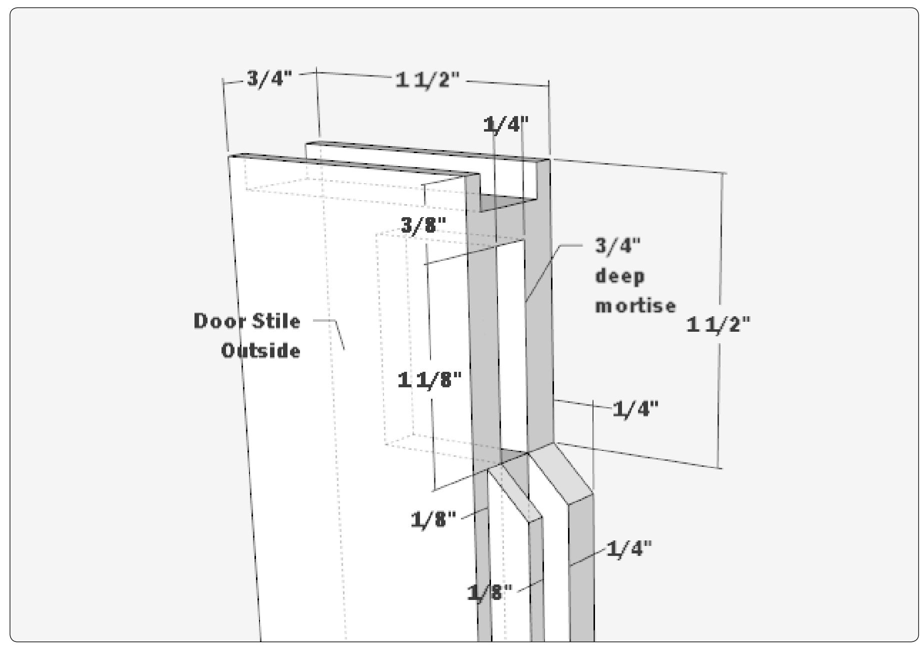


Figure 120. *Measurements for the joinery at the upper end of the door stile.*

out the waste, as shown in Figures 114 and 115. This makes the miter on the front half of the corner. Repeat the procedure to make a miter on the rear of the rail. See Figure 116.

Step 52 Copy the tenon and miters to the other end of the rail. Draw a selection box from left to right around the tenon end of the rail. Be sure that the miter joint falls within the box. With the Move/Copy Tool, tap the Ctrl key (Option on Macs) to copy the selection and move it beyond the other end of the rail. See Figure 117.

To mirror the copied joinery, right-click on the selection and choose flip along and then red direction from the pop-up menus. Use the Move/Copy Tool to connect the selection to the end of the rail. Use the Eraser Tool to delete any waste edges and faces. The lower face of the tenon will need to be re-created by drawing a line over one of the tenon edges. Figure 118 shows the completed joinery.

Step 53 Follow the procedures in steps 48 through 52 to create the middle and lower door rails. In this instance, it's faster to draw each rail separately rather than to draw one, copy and modify it, and then make it a new component.

Step 54 The two stiles are identical in size and shape. One has sockets for the door handle; the other, a channel for the hinge. You will add those details later.

Be sure the stile resembles the one in Figure 107, with ¼-in.-deep notches for the rails and a width of 1¾ in. between notches.

As you did to make the rails, make one stile face a component. Copy the compo-

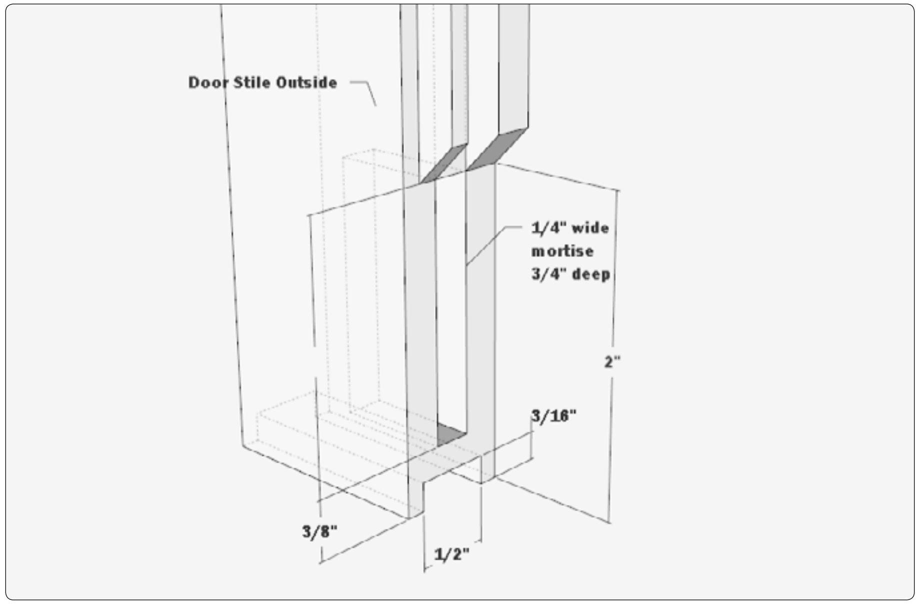


Figure 121. *The lower joinery of the door stile.*

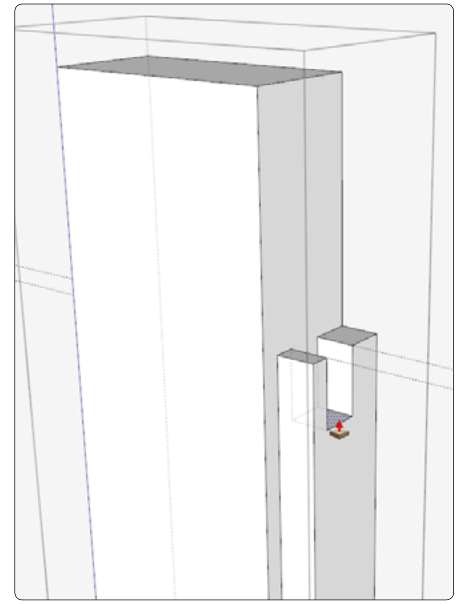


Figure 122. *Create the rabbet and the groove in the stile.*

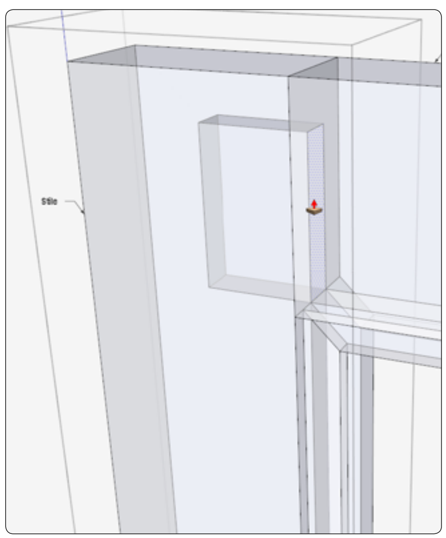


Figure 123. *Trace over the tenon end, then push out the mortise.*

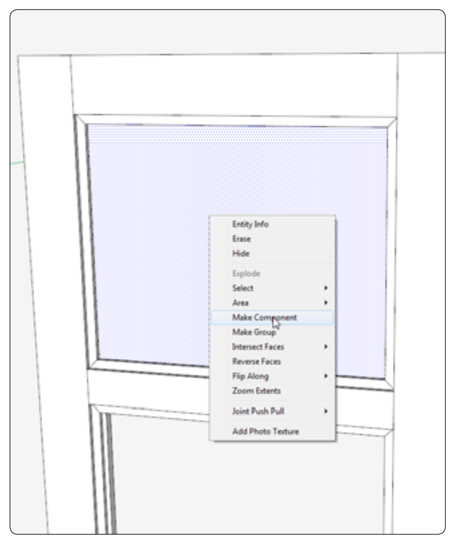


Figure 124. *Draw around the perimeter and make the rectangle a component.*

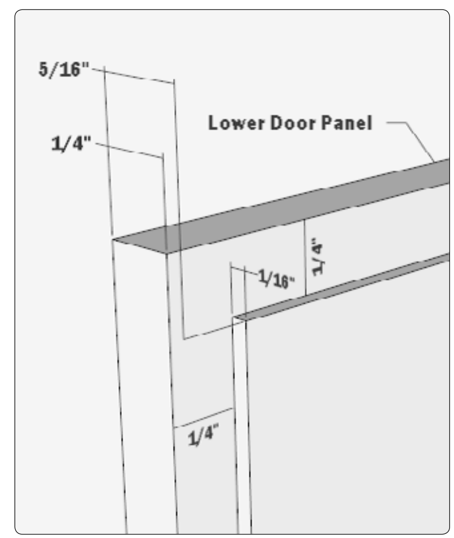


Figure 125. *Rear view of the door panel with 1/16-in.-deep rabbet.*

nent, move it away from the model, and give it a thickness of ¾ in. See Figure 119.

Again as you did with the rails, make the ⅛-in.-deep rabbet in the front face of the stile. Use the Tape Measure Tool to place guidelines defining the grooves for the floating panels. With the Push/Pull Tool, push the groove through. You will have to do this once for the upper panel groove and again for the lower panel. See Figure 122. Also create the miter joints at the ends of the rabbets, using the procedure from step 51.

Step 55 Connect the rails to the stile, using the Move/Copy Tool. Use the tenons in the rails to make the mortises in the stile. Turn on X-Ray from the Styles toolbar and open the stile component for editing. Zoom in close to the upper joint. Use the Line Tool to trace over the shape of the tenon, then use the Push/Pull Tool to drive the mortise the length of the tenon. See Figure 123. Repeat this procedure with the other two rails.

Copy the completed stile component, execute a flip along command, and connect it to the other end of the rails.

Step 56 To create the upper floating panel, draw a rectangle around the inside opening of the door frame, between the upper and center rails. Right-click on the rectangle and choose make component from the pop-up menu. See Figure 124. Make a copy and move it away from the door frame. Open the copy and use the Push/Pull Tool to make the panel 5⁄16 in. thick.

Still working on the copy, use the Push/Pull Tool to extend each side by 3⁄16 in., so the panel will seat in the frame's groove but leave space for seasonal expansion. Around the perimeter of the door panel, on the exterior face, create a 1⁄16-in. rabbet ¼ in. wide. See Figure 125.

Step 57 Use the upper door panel to create the lower one. See Figure 126. Copy the upper panel and position it accurately within the lower door opening. Explode this component and make it a new one named lower door panel.

Open the new component for editing and place a guideline 3⁄16 in. above the lower edge, as shown in Figure 127. Draw a selection box around the bottom edge of the panel. Select the Move/Copy Tool and click it on the intersection of the guideline and the stile. See Figure 128. Pull the length of the panel downward. Click the Move/Copy Tool on the corner of the lower miter joint of the stile, as shown in Figure 129.

This completes the door components.

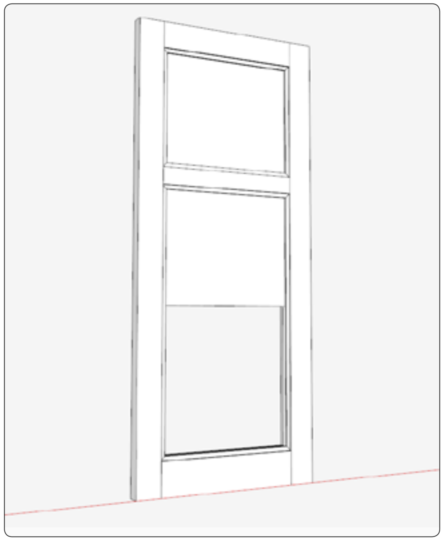


Figure 126. *Copy and move the upper panel.*

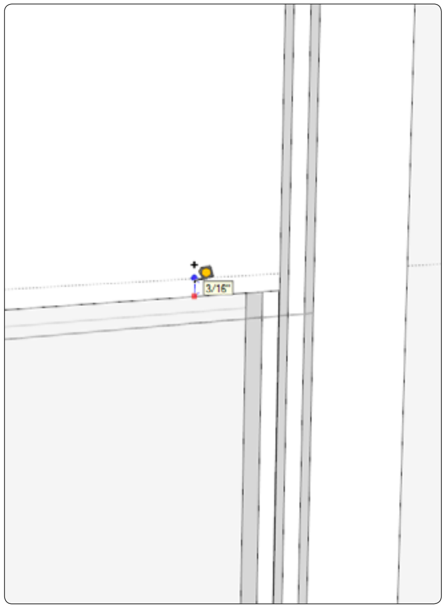


Figure 127. *Place a guideline 3⁄16 in. above the bottom edge of the panel.*

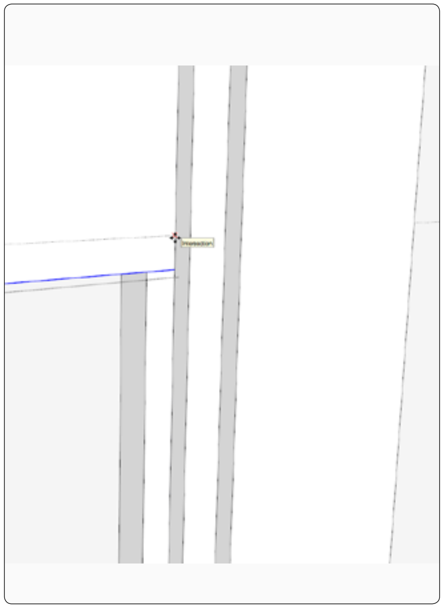


Figure 128. *Use the Move/Copy Tool to stretch the panel length.*

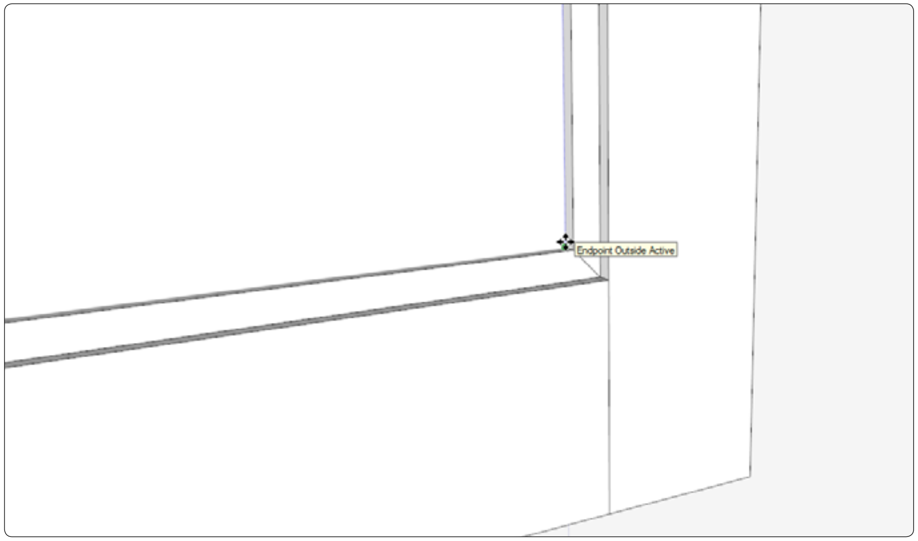


Figure 129. *Stop stretching when the Move/Copy Tool icon snaps to the bottom corner.*

Section 8. The Door Handle and Hinges

These are the final pieces needed to complete the wall cabinet. The handle is Gochnour's original handmade design. It has square tenons that fit into sockets in the door stile. The hinges are contemporary knife hinges, which require careful layout and positioning.

Making the handle will introduce you to another use for the Follow Me Tool: Extruding a profile around a circular path to create a turning.

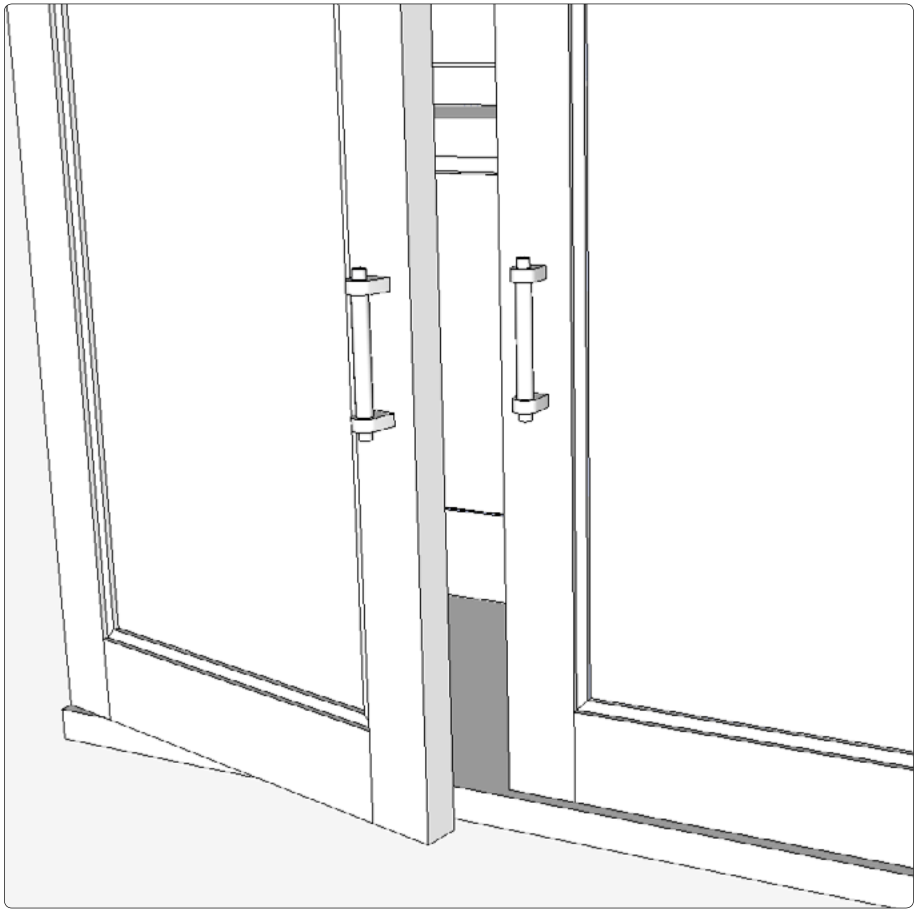


Figure 130. *The door handles installed on the cabinet.*

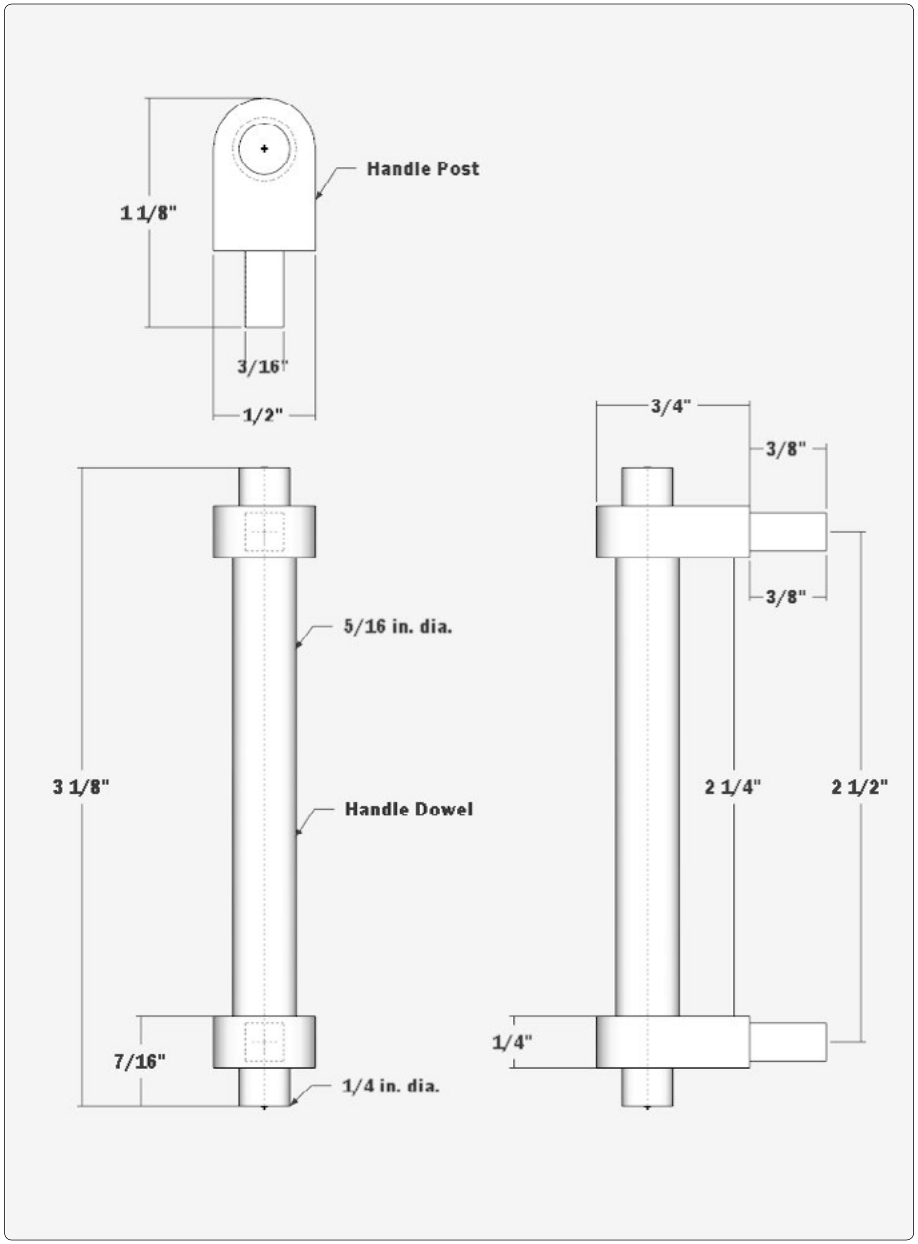


Figure 131. *The measurements for the door handle.*

The Door Handle and Hinges

The wooden door handle has only two unique components, the dowel and the post. Figure 131 gives dimensions for the assembled handle.

Step 58 Make the dowel first. Draw a rectangle on the red-blue axes that is 3⅛ in. high and 5/32 in. wide (one-half the widest diameter of the dowel). The ends of the dowel are ¼ in. in diameter. Place guidelines to show this reduction in diameter, which extends 7/16 in. from the ends. Extend the lines at the center of the turning past the profile. Make the profile a component. See Figure 132.

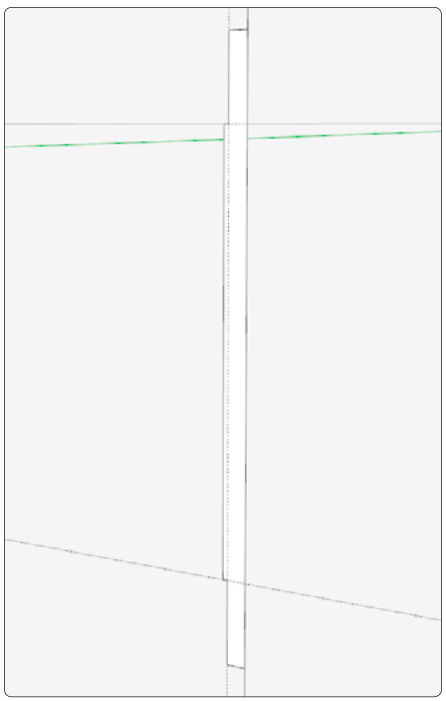


Figure 132. *Draw the dowel profile ready for a follow me command.*

Draw the circular path, centered on one of those extended lines. Be sure the cursor for the Circle Tool is blue.

Select the path, then the Follow Me Tool. Right-click the tool on the dowel profile and choose edit component from the pop-up menu. Click on the profile face, as shown in Figure 133. The dowel is "turned" instantly, as shown in Figure 134. If the turning looks blue, triple-click on it and choose reverse faces from the menu.

Step 59 To make the post, begin by drawing a rectangle ½ in. wide and 1⅛ in. tall on the red-green axes. Make it a component called post. Place guidelines to help with the layout of the shape, as shown in Figure 135. Use the Circle Tool to draw a ½-in.-diameter circle to shape the top of the post. Use the Eraser Tool to remove waste. I like to add

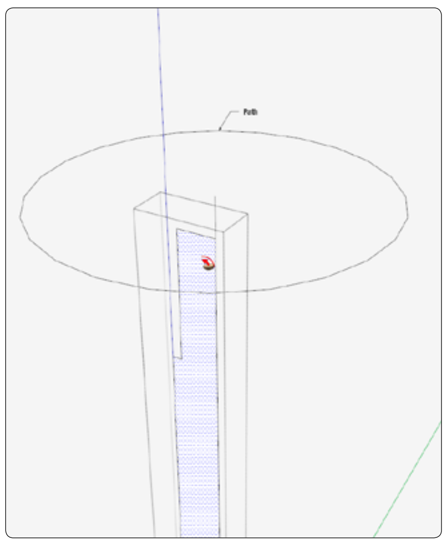


Figure 133. *Create and select the circular path. Then choose the Follow Me Tool.*

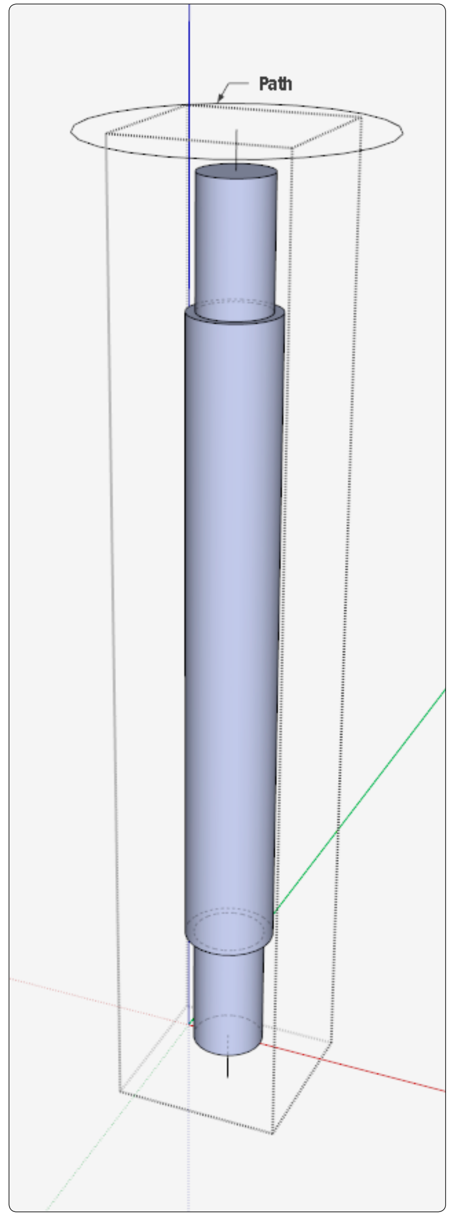


Figure 134. *The resulting turning of the dowel.*

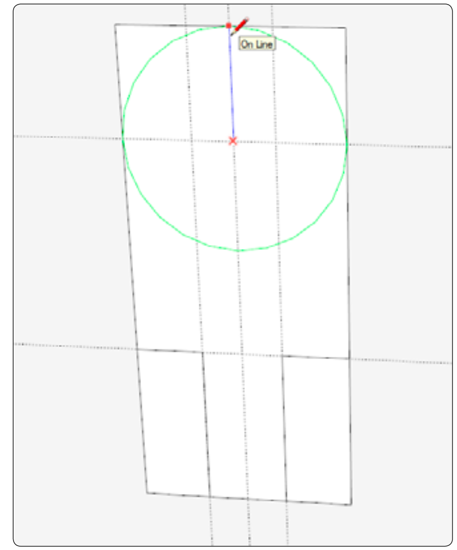


Figure 135. *Lay out the shape of the post.*

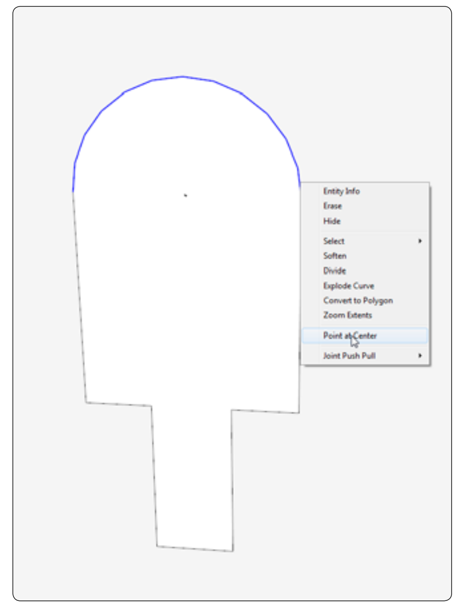


Figure 136. *Erase waste and create a guide-point at the center of the circle.*

guide points showing the centers of circles, which helps when connecting components. To create the guide point, right-click on the outer edge of the circle and choose point at center from the menu. See Figure 136.

Use that center to draw second circle, ¼ in. in diameter, which will make a hole for the dowel. See Figure 137.

Use the Push/Pull Tool to make the post ¼ in. thick (Figure 138). Draw a line at the end of the tenon on each face, then use the Push/Pull Tool to move each tenon face in 1⁄32 in., making the end 3⁄16 in. square.

Use the Move/Copy Tool to grab the post at the center of the hole and move it to one end of the dowel. When it is flush with the end of the dowel, move it down 3⁄16 in. until it touches the shoulder of the dowel. Copy the post and move it down the handle to the opposite end. Select all those elements and make the assembly a component called door handle.

Step 60 The door handle is placed on the inside stile and requires two 3⁄16-in.-square sockets, ⅜ in. deep, in the stile. The midpoint of the handle aligns with the midpoint of the lower door panel.

Explode the inside stile in the door assembly and make it a new component named door stile inside. Lay out and create the slots, as shown in Figure 139.

I think the best way to position the door handle in the stile is to turn on the X-Ray style and grab one of the inside corners of the post tenon with the Move/Copy Tool, as shown in Figure 140. Begin moving the handle toward the stile and tap the Left arrow key. This constrains the movement along the green axis. Continue moving the handle

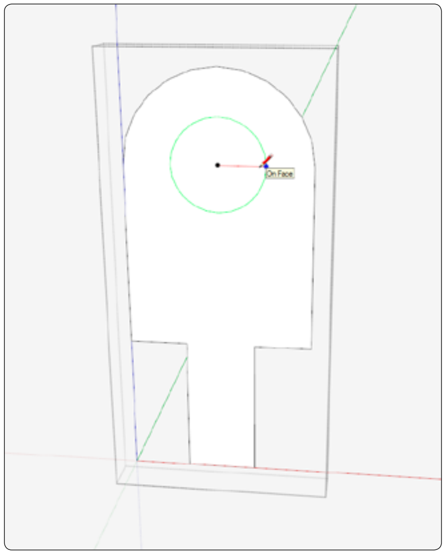


Figure 137. *Create a ¼-in.-diameter hole to hold the dowel.*

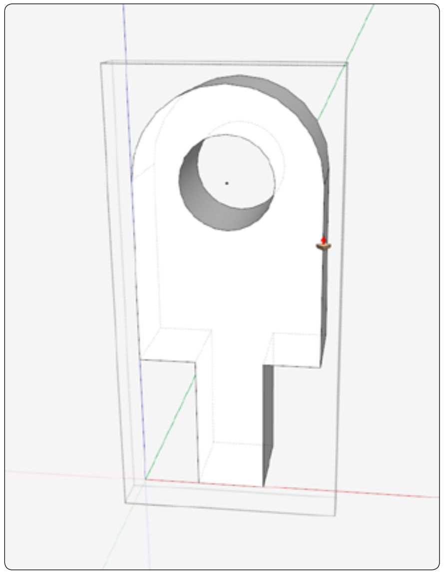


Figure 138. *Use the Push/Pull Tool to make the post ¼ in. thick.*

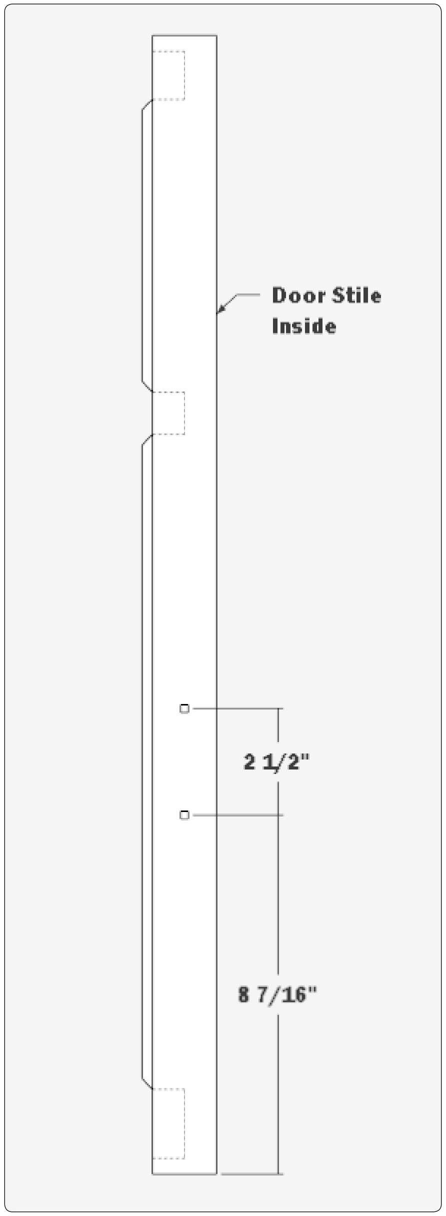


Figure 139. *The inside door stile with the two sockets for the door handle.*

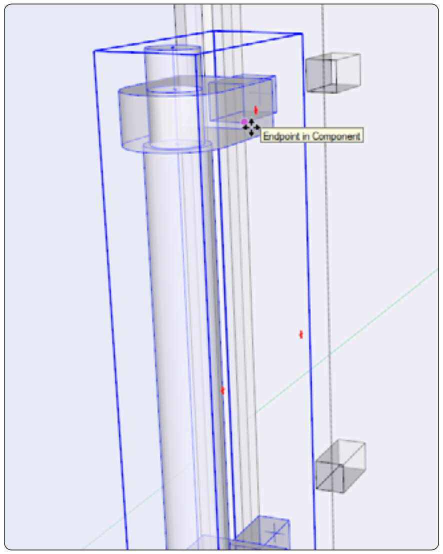


Figure 140. *Grab a corner of the post tenon and connect it to a corresponding socket.*

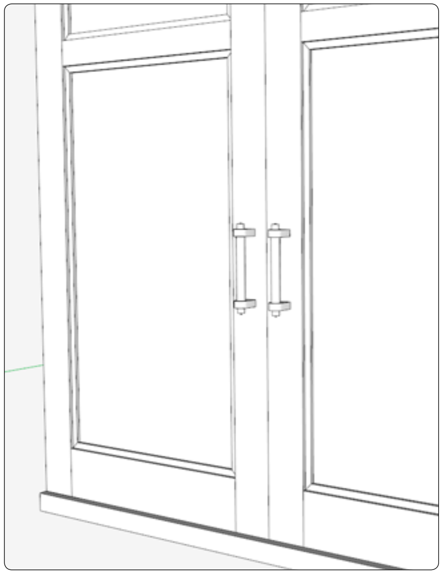


Figure 141. *The handles in place on the assembled door.*

until the Move/Copy Tool latches onto the corresponding corner of the stile's slot.

Step 61 Tinish the cabinet by installing the hinges. Gochnour chose brass knife hinges that attach to the ends of the door stiles. This hardware is the only feature of the cabinet that is not traditional. I think you could substitute traditional butt hinges without harming the cabinet's appearance. In the shop, butt hinges allow you to glue up the carcase earlier in the construction process. The mortises for knife hinges are best cut when the carcase is dry-fit, not glued up.

Gochnour did not specify a manufacturer or catalog number for the hinge. For this model, I chose a Brusso™ hinge, catalog number ST-80. I found Brusso's detail drawing at its website and built a model of it, as shown in Figure 141.

Before building this cabinet, I recommend buying the hinge hardware so you can incorporate its precise dimensions into your SketchUp model.

Once you have hinges on hand, you can cut the channels in the stile ends (shown in Figure 143) and in the carcase top and bottom. Gochnour recommends leaving a 1⁄16-in. gap between the door and the edge of the case. You can see the gap in Figures 144 and 145.

Note that the end of the hinge extends beyond the edge of the door. This will require a corresponding slot in the bottom edge of the cove molding. See Figure 144.

With the Rotate Tool, you can rotate the door on the hinge axis. I've shown an X-Ray and top-down view in Figure 146.

This completes the modeling of the wall cabinet.

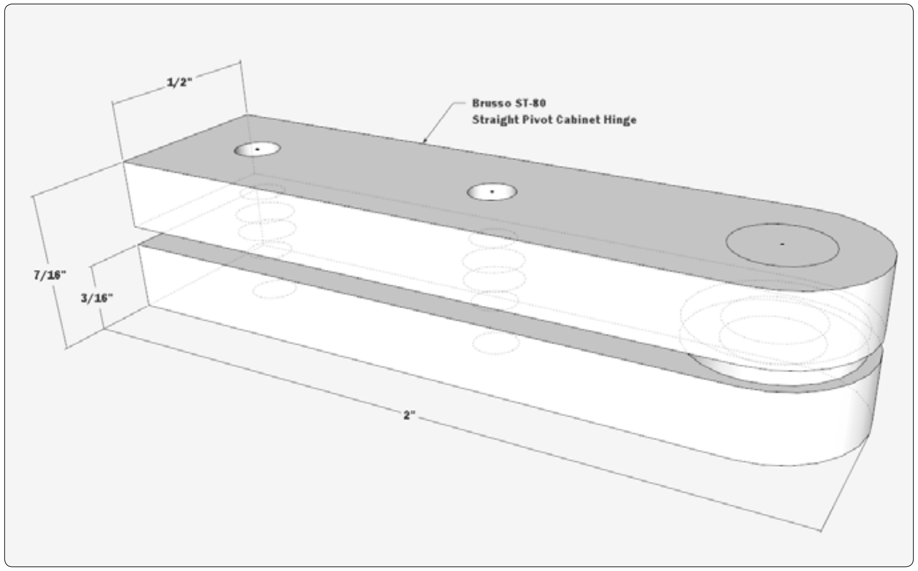


Figure 142. *The SketchUp model of the Brusso ST-80 knife hinge.*

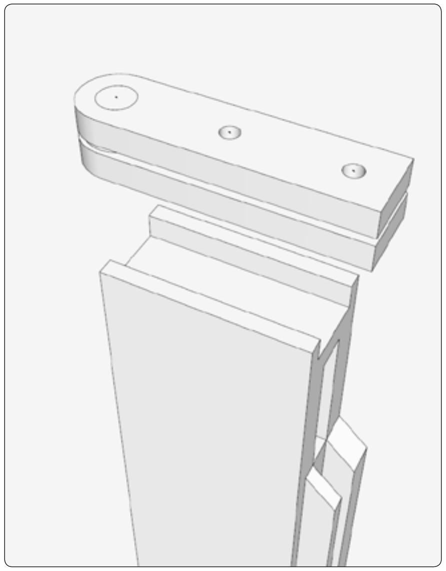


Figure 143. *Cut channels for the hinges in the stile ends, the top, and the bottom.*

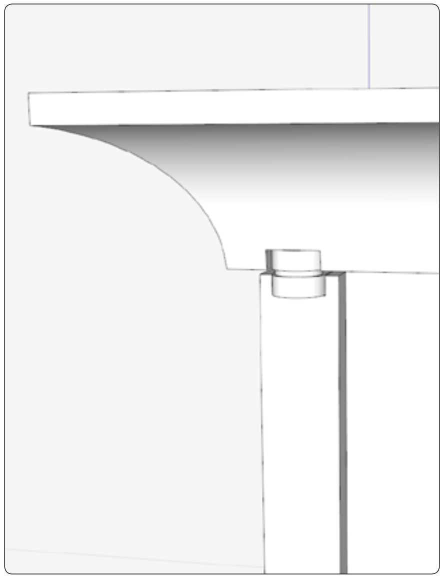


Figure 144. *The hinge installation at the top.*

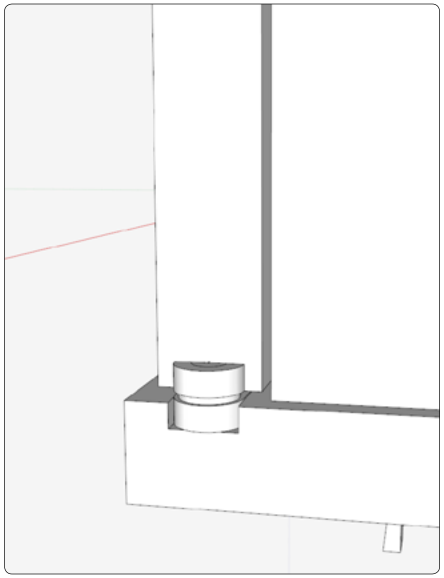


Figure 145. *The hinge installation at the bottom.*

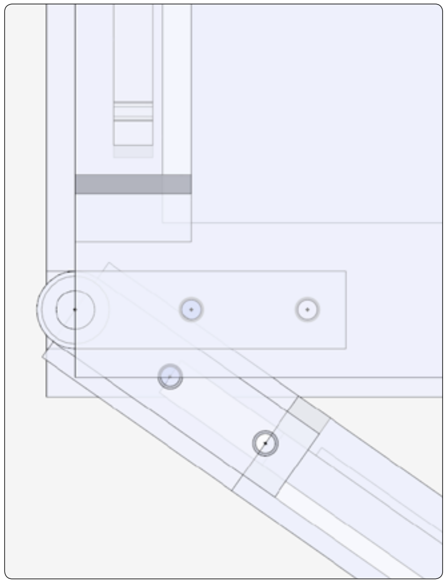


Figure 146. *Top X-Ray view of rotated door and hinge.*

A Display Case in the Arts and Crafts Style

I can remember a box of *Craftsman* magazines in my father's workshop. He was a weekend woodworker who occasionally built furniture based on drawings in the magazine. *Craftsman* was the creation of Gustav Stickley, the leading champion of the Arts and Crafts movement in the U.S. He published *Craftsman* from 1901 to 1916, but the style he promoted remains influential. A perfect example is this display case. It was designed and built by Michael Pekovich and featured in the March/April 2010 issue of *Fine Woodworking* magazine.

In my own woodworking, I have to admit to taking a different direction, outfitting our house in 18th century and Shaker pieces. Nevertheless, I am awestruck by the beauty and utility of Arts and Crafts furniture.

There are great examples of Arts and Crafts style in the western U.S., where we live. The San Francisco area has numerous homes and buildings by famous Arts and Crafts architects, including Greene & Greene, Bernard Maybeck, and Frank Lloyd Wright.

In Yosemite National Park, we don't miss a chance to walk through the Ahwahnee Hotel, closely inspecting its beautiful furniture. In the summer of 2011, we visited Old Faithful Inn at Yellowstone National Park. It holds a fantastic display of Arts and Crafts furnishings.

Pekovich says he builds a large project like this by starting from the outside and working his way in. That is exactly how we will tackle the project in SketchUp.

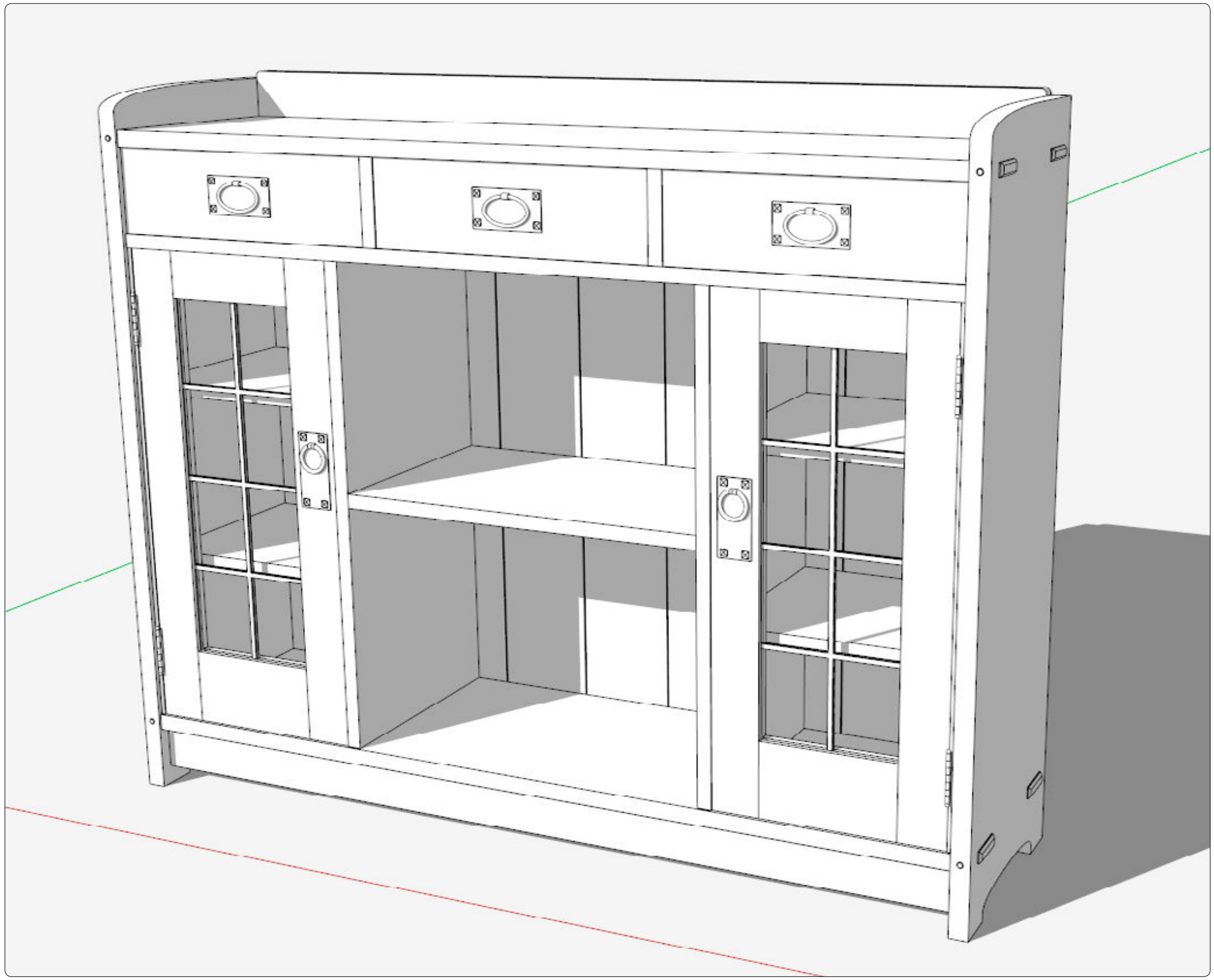


Figure 1. *The finished display cabinet model in SketchUp.*

Quantity	Description	Length(L)	Width(W)	Thickness(T)
Carcase				
1	Top	48 3/8"	12 7/8"	7/8"
2	Side	38 1/2"	13"	1"
1	Apron	47 1/2"	2 3/8"	7/8"
1	Rear Apron	47 1/4"	3 3/8"	7/8"
7	Back Slat	32 3/4"	5 1/2"	3/8"
2	Back Slat End	32 3/4"	5 5/8"	3/8"
1	Shelf	19 3/4"	12 1/4"	3/4"
4	Side Shelf	12 3/8"	11"	3/4"
1	Back Splash	47 1/2"	2 1/2"	7/8"
1	Bottom	48 3/8"	12 3/8"	7/8"
2	Vertical Divider	26 1/2"	12 1/4"	3/4"
1	Horizontal Divider	47 1/2"	12 5/16"	3/4"
Door				
	Came (Lead)			1/4"
2	Door Rail	10 1/8"	2 1/2"	7/8"
2	Door Rail Bottom	10 1/8"	4"	7/8"
2	Door Stile	26"	2 1/2"	7/8"
2	Door Stile (Hinged)	26"	2 1/2"	7/8"
2	Door Stop	1 1/8"	7/8"	7/8"
4	Glass Stop Long	20 1/4"	3/8"	3/8"
4	Glass Stop Short	7 1/8"	3/8"	3/8"
2	Hinge Strip	26"	7/8"	1/4"
4	Zinc Rail	7 3/8"	1/4"	1/4"
4	Zinc Stile	20 1/4"	1/4"	1/4"
Drawer				
1	Drawer Back Center	15"	3 7/8"	5/8"
2	Drawer Back SIde	14 3/4"	3 7/8"	5/8"
1	Drawer Bottom Center	14 1/4"	11 11/16"	3/8"
2	Drawer Bottom Side	14"	11 11/16"	3/8"
2	Drawer Divider	5"	12 1/4"	3/4"
1	Drawer Front Center	15"	4 1/2"	7/8"
2	Drawer Front Side	14 3/4"	4 1/2"	7/8"
6	Drawer Side	11 15/16"	4 1/2"	5/8"

Figure 1a. *The cutlist for the Arts and Crafts display case.*

Figure 1b. *The original display case, by Michael Pekovich.*

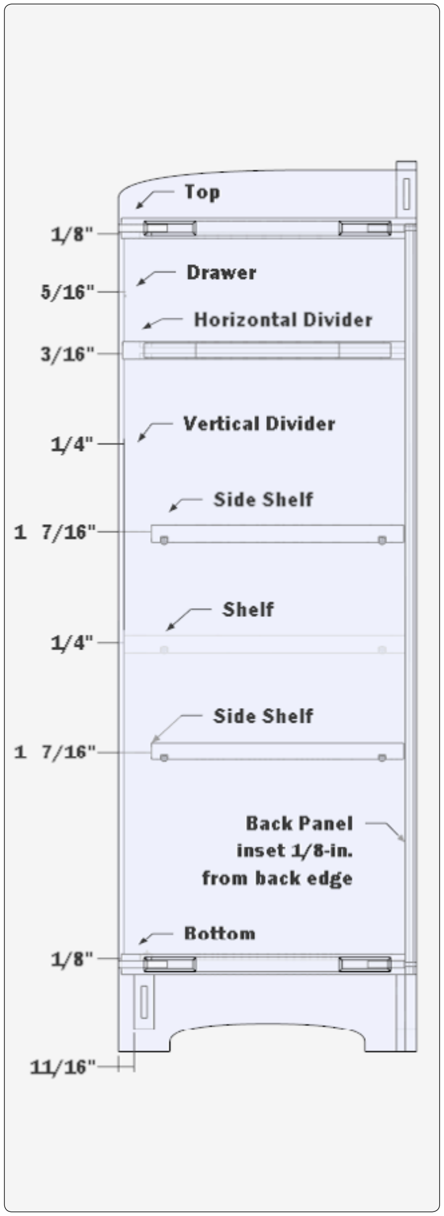


__Figure 2.__ Shelves and dividers are inset from the front and back of the case.

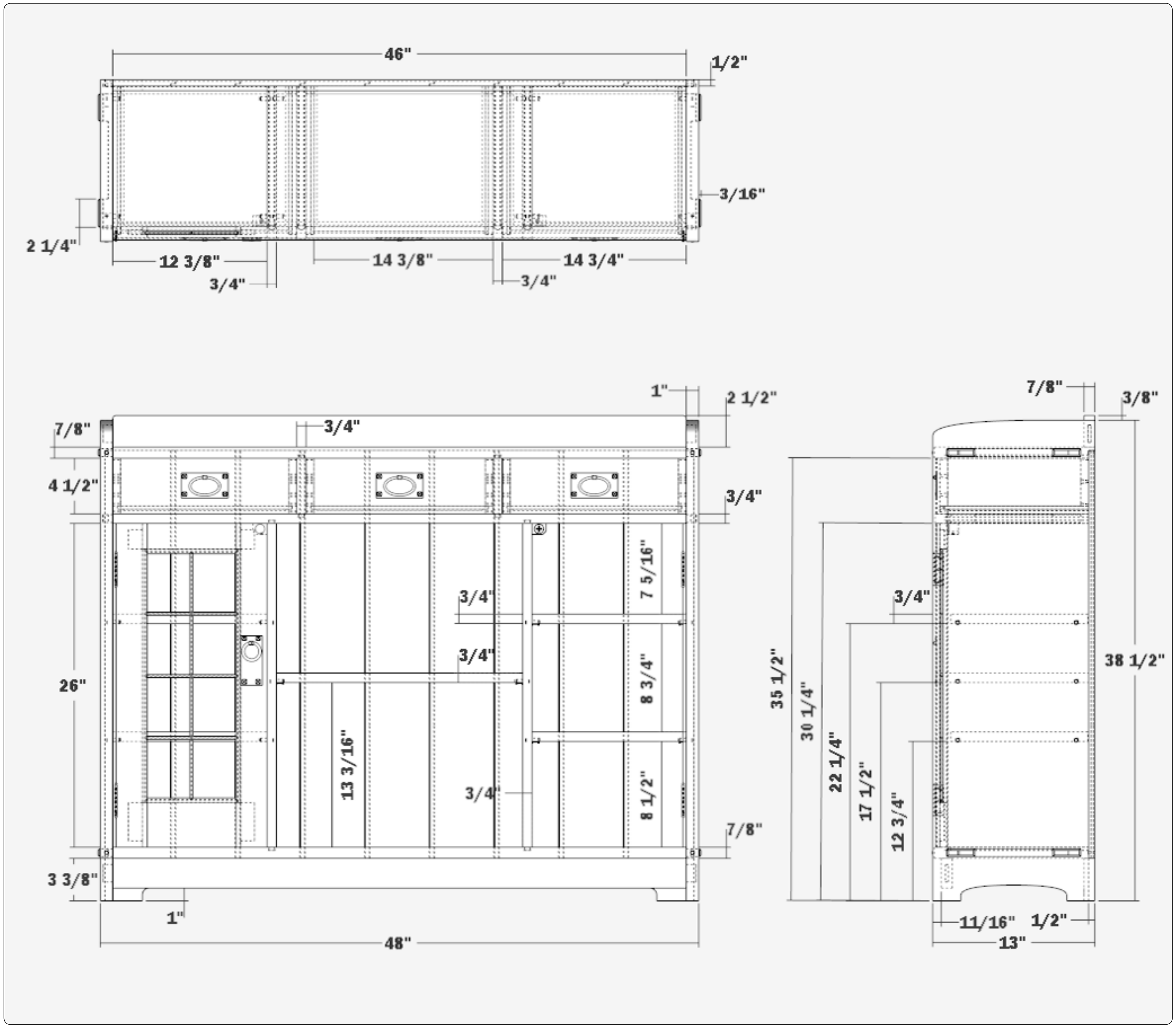


__Figure 3.__ Standard orthographic views in SketchUp's Back Edges style. The right door is hidden in the front view to show the shelf details.

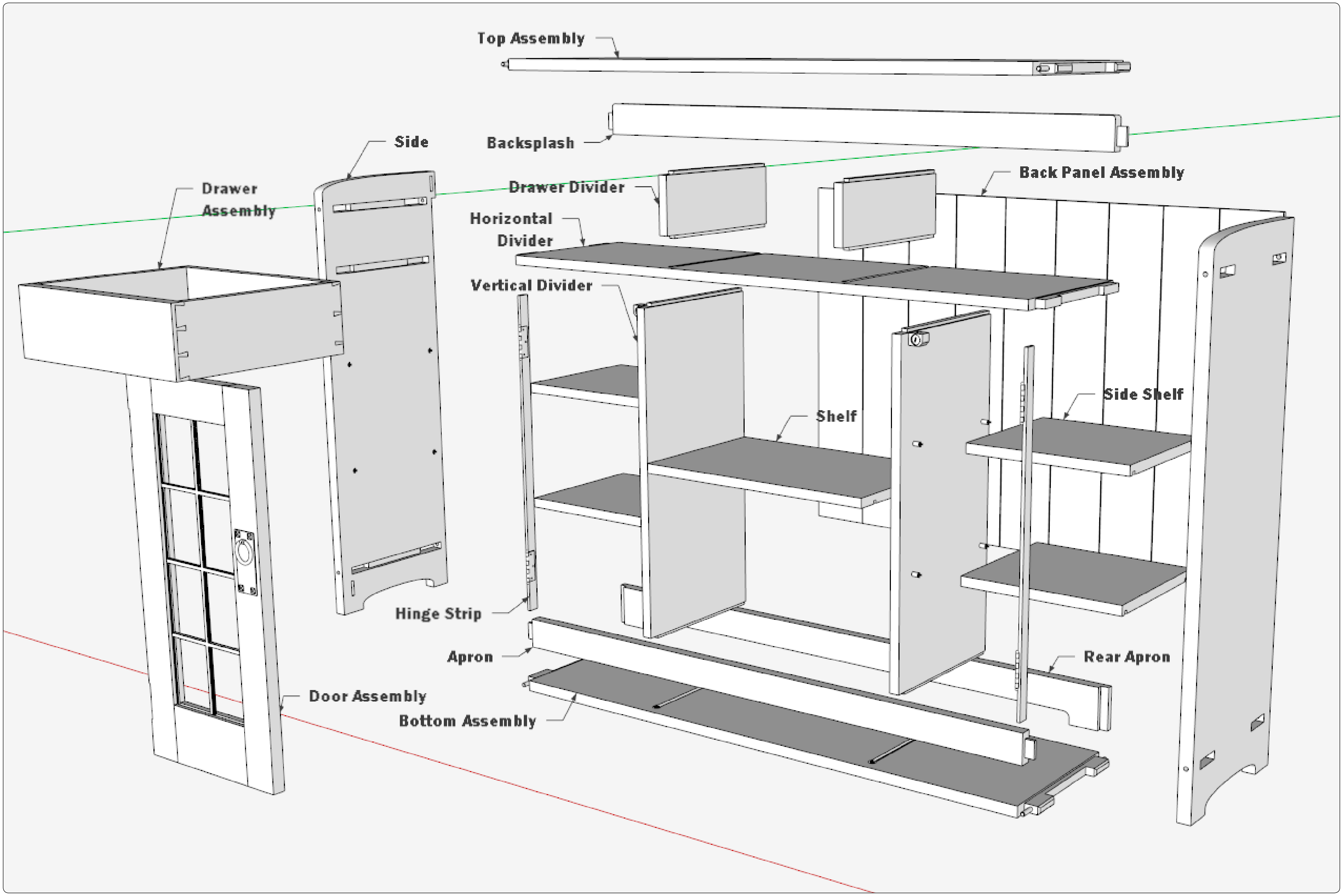
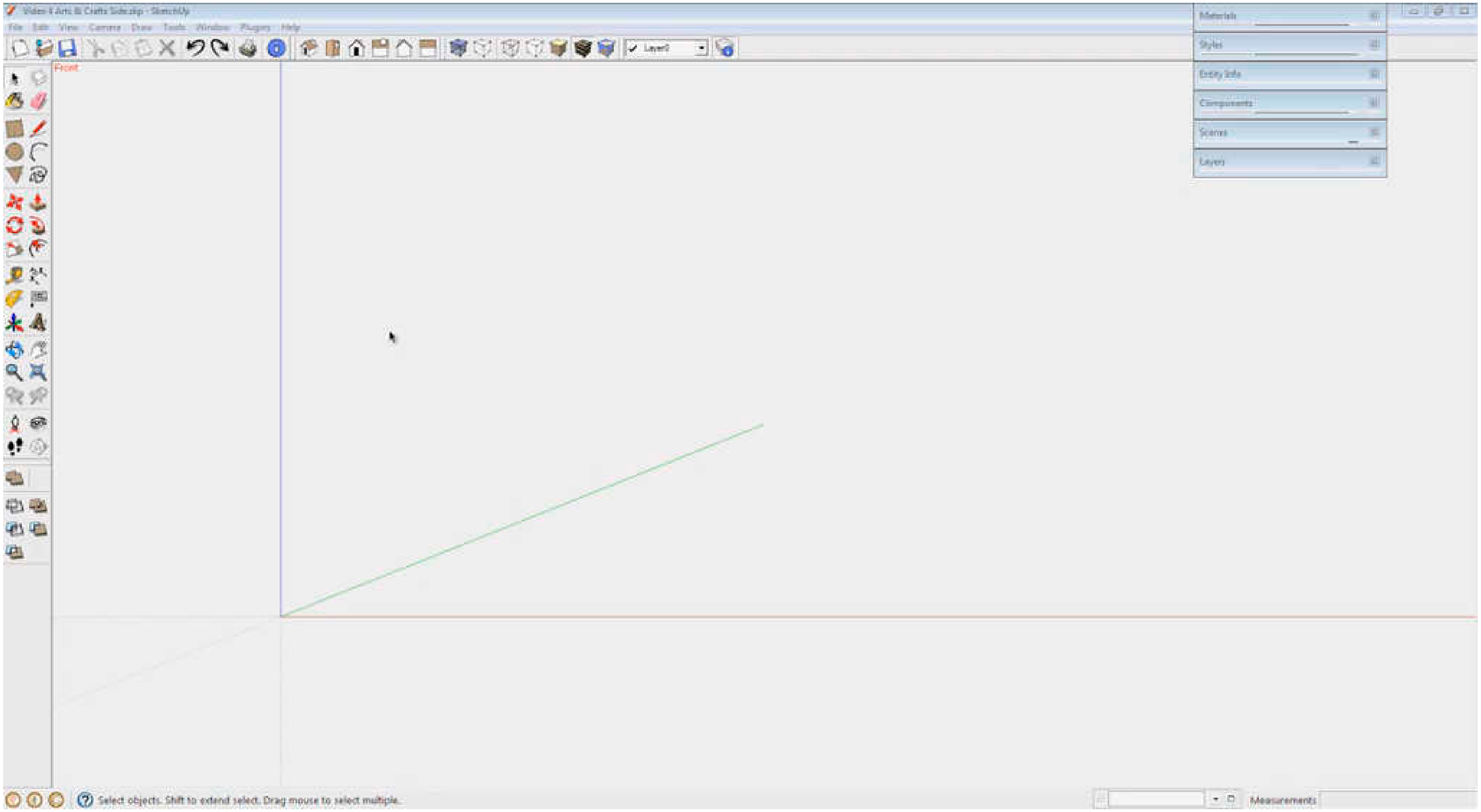


Figure 4. An exploded view of the display case.

Video Tutorial: Creating the Case Side

We'll begin the SketchUp build with a video showing how to create the side component. To render the curved top and the cutout at the base properly, it's best to work directly from the original plan. To do that, you scan the image, import it into SketchUp, and scale it to full size. Then you use SketchUp's basic drawing tools to trace the image.



Create the Case Side

The magazine article shows the case side in both perspective and in flat template-like drawings. The flat drawing is the one to import into SketchUp because it gives the dimensions for the joinery. (Members of FineWoodworking.com can access the article as a PDF file, extract the appropriate page, and use it as the basis for the image import.) If you don't have the magazine, you can use Figures 2 or 3.

Step 1 Scan the image or save the PDF to create a .jpg or .png file. Crop it close to the drawing to remove most of the background.

Open SketchUp. Click on File, and choose Import from the menu. Figure 5 shows the dialog box that will appear. It gives you three options for importing images; choose Use as Image, click on the thumbnail of the image you scanned, then click on Open. Be sure the image is aligned with SketchUp's red and blue axes. If it needs adjustment, use the Rotate Tool to position the image properly.

Step 2 Use the Tape Measure Tool to make the imported image full size. Select the tool and tap the Ctrl key (Option on Macs). Click the mouse on the lower right-hand corner of the side. Drag the Tape Measure Tool to the top of the side along the right edge. Be sure you stay on the blue axis. Click on the upper right-hand corner of the image. You will see the measured length of the side in the Measurement Box. Don't worry if it is very different from the proper length. Type the proper length of the right edge—38½ in.—and press Enter.

Figure 6 shows the dialog box that will appear asking if you want to re-size the model. Choose Yes. The image will now be full size in SketchUp.

Step 3 You are ready to begin tracing over the scanned image. Begin by using the Line Tool to draw the bottom edge of the side, following the scanned image. Extend the line past the sides of the image; that helps locate intersecting lines. Be sure the line follows the red axis. Draw the right vertical edge, following the blue axis.

To make it easier to see the tracing lines, I sometimes create a special style. In the Edge settings, I change the color of the edge to red and set the edge profile to 3. See Figure 7.

Place a guideline parallel to the line for the back edge and 13 in. from it. Place another

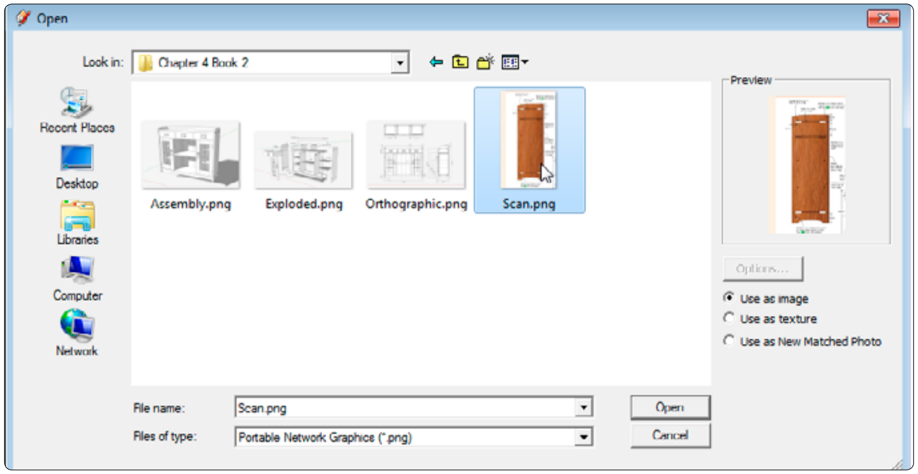


Figure 5. *Import the scanned image of the case side. Choose the option Use as Image from the list under the Preview window.*

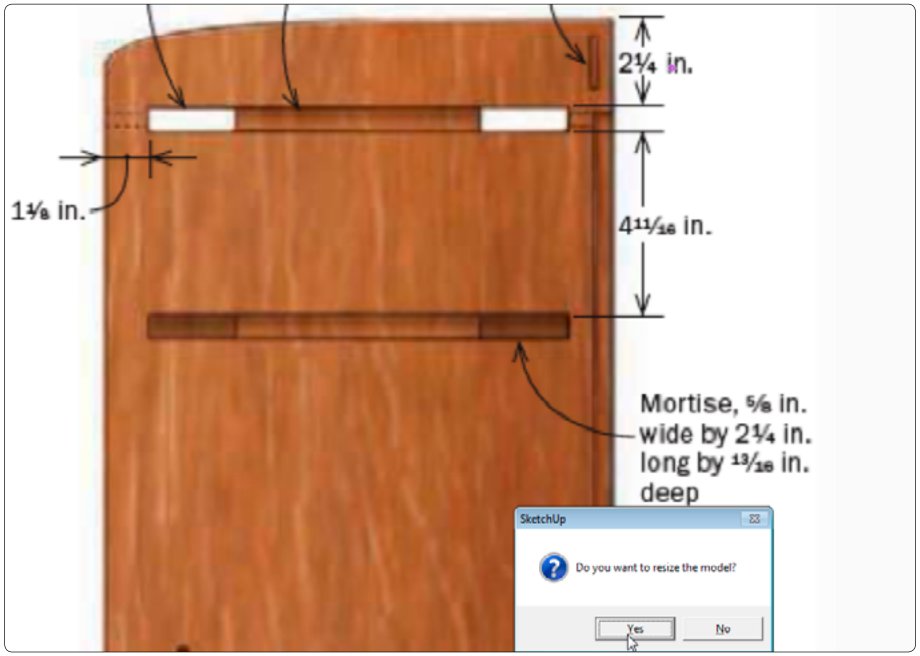


Figure 6. *Use the Tape Measure Tool to resize the imported image to make it full size. When the dialog box shown here appears, click Yes to change the image size.*

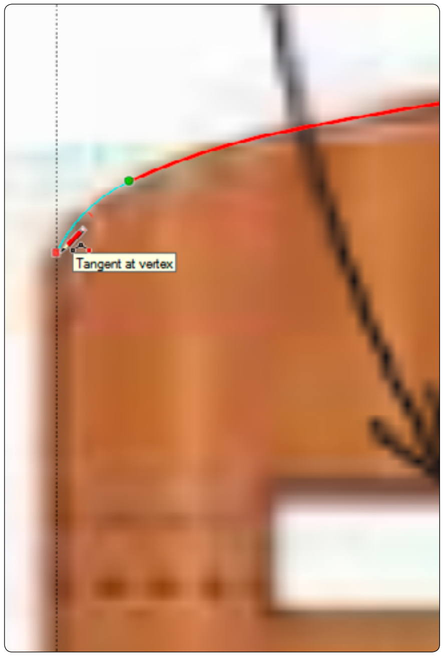


Figure 7. *Using the Arc Tool to trace the curve on the upper edge.*

guideline 38½ in. from the bottom edge. These guides provide accurate boundaries for the other edges, forming the side.

Step 4 Use the Arc Tool to create the rounded shape on the upper edge, as shown in Figure 7.

SketchUp provides two aids to help ensure that the arcs are in the proper plane. First, the color of the path that you make with the tool changes to cyan when the arc is tangent to the end of the previous arc or edge. Second, you will see a small box reading "Tangent at Vertex" next to the cursor. The box signals that the arc is aligned properly.

When tracing shapes like this, I connect multiple arcs to complete the curve. In this case, I draw one straight line about 5 in. long, then draw three connected arc segments, following the edge of the imported image as closely as possible. You can also use a bezier plug-in to draw curves, but I find it just as easy to use the Arc Tool.

Follow the same procedure to create the cutout shape in the bottom end of the side. See Figure 8.

To ensure that the cutout is symmetrical, I only trace half of the shape. I copy the half-shape, execute a flip along command to mirror it, and connect it in place to create the entire cutout.

Step 5 Using the dimensions given in Figures 9, 11, and 13, place guidelines on the traced-over face of the side to locate the mortises and rabbet for the back panel assembly. Then use the Line Tool to draw rectangles at all those locations. Figure 8 shows the completed traced-over shape of the side. When placing lines for the mortise

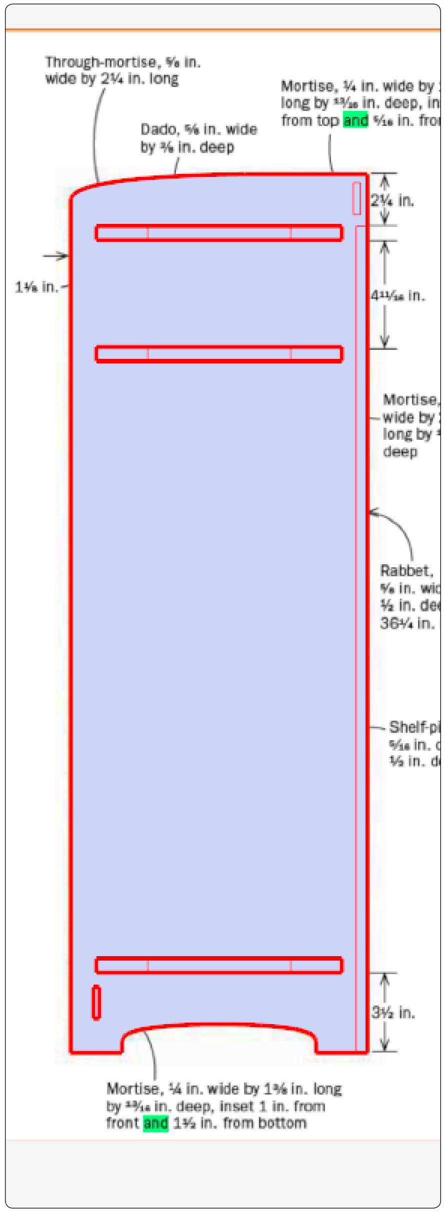


Figure 8. The finished traced-over shape of the side, with joint locations.

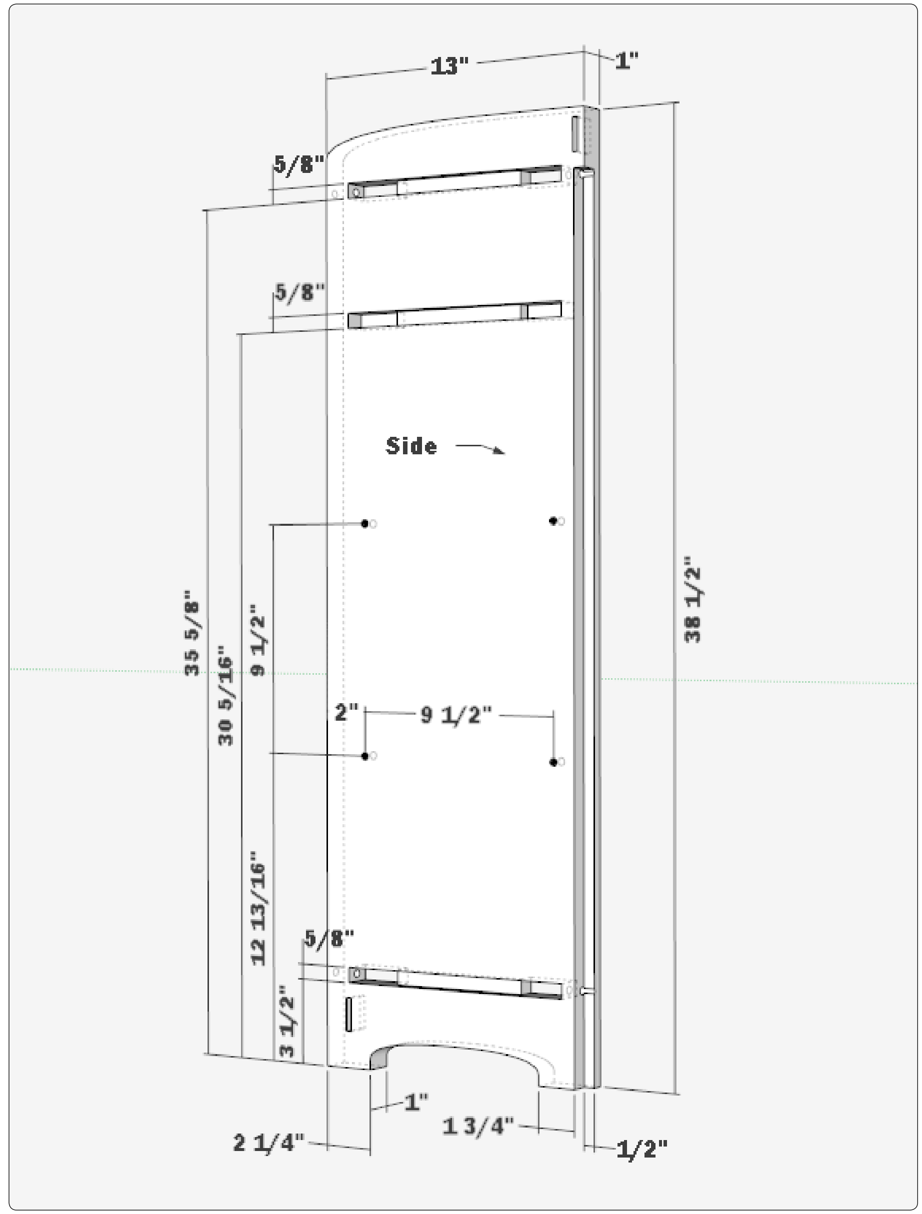


Figure 9. Follow these dimensions to position the mortises and rabbet in your tracing of the side component.

locations, it is helpful to change to an X-Ray style to see the underlying scanned image.

Step 6 Select the traced-over shape, copy it, and move the copy to one side. It was drawn on the red-blue plane, so you need to rotate it 90 degrees to align it with the green-blue plane. This orients the side properly for the rest of the build. See Figure 10.

Based on dimensions and notes in Figures 11 and 13, use the Push/Pull Tool to give depth to the side and all its joinery. Make it a component. See Figure 12.

The joinery is now complete on the side component. You may find that it needs some touch-up and cleanup, however. The surfaces inside the mortises will probably

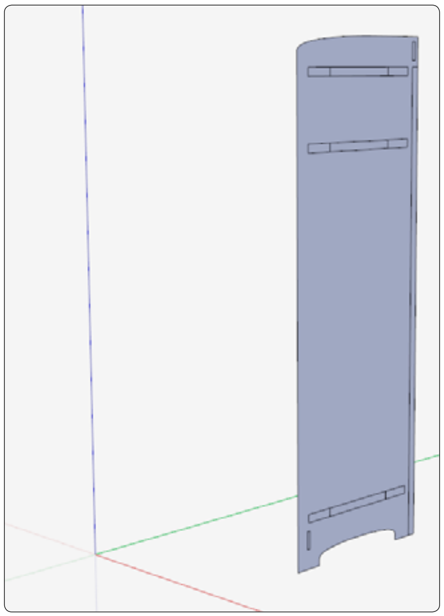


Figure 10. *Copy the traced-over shape and rotate it to align with the green-blue plane.*

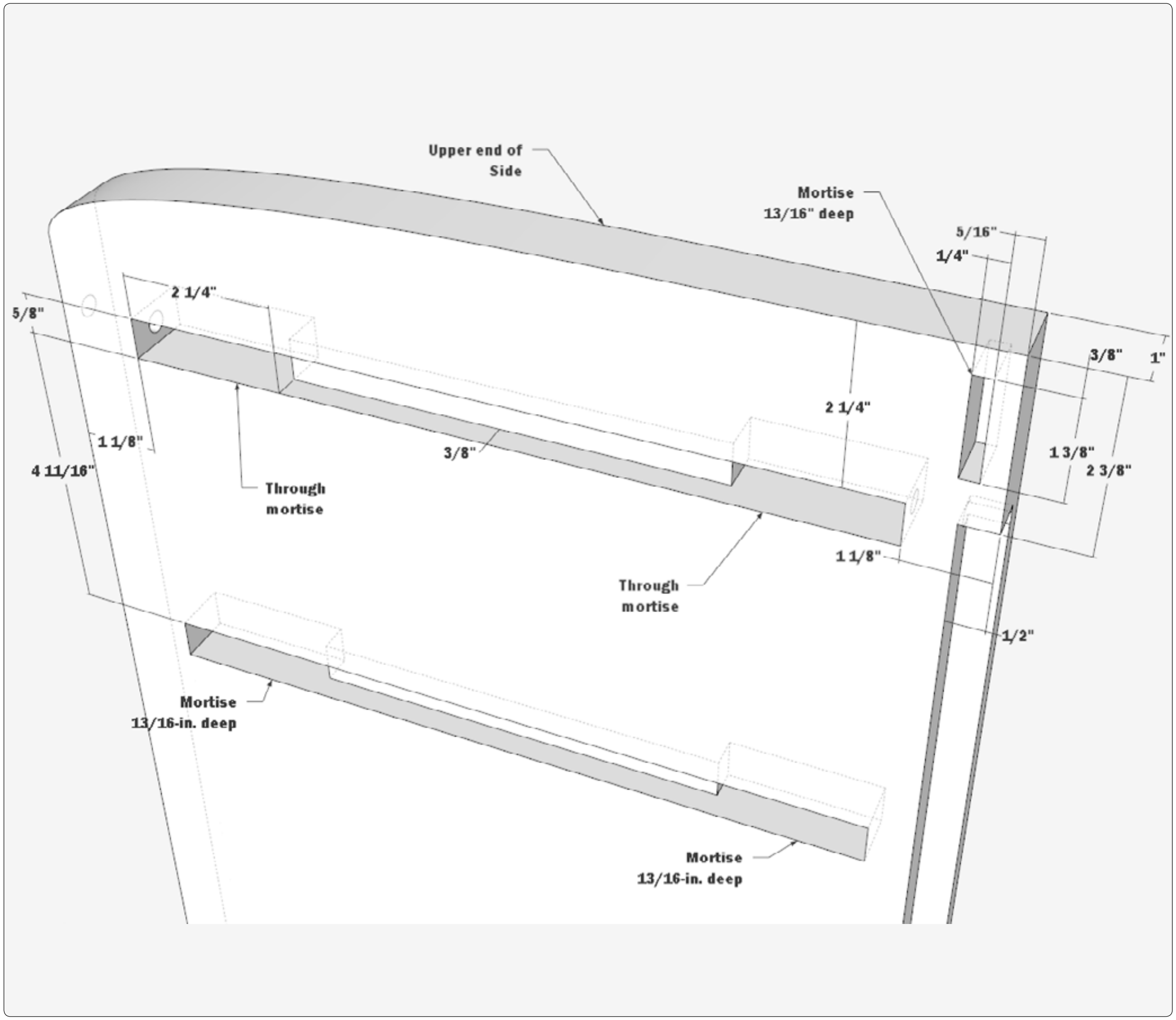


Figure 11. *Dimensions of mortise locations in the upper section of the side.*

appear in blue and should be reversed to white (click to highlight the face, then choose Edit>Face>Reverse Faces). Also, since I used several arc segments for the bottom and top shapes, there will be extra lines across these edges that need to be softened and smoothed. Check the opposite (outside) face of the side. There may be extra lines that should be removed. Change to X-Ray view and check that there are no extra lines inside the component.

This completes the creation of the side component.

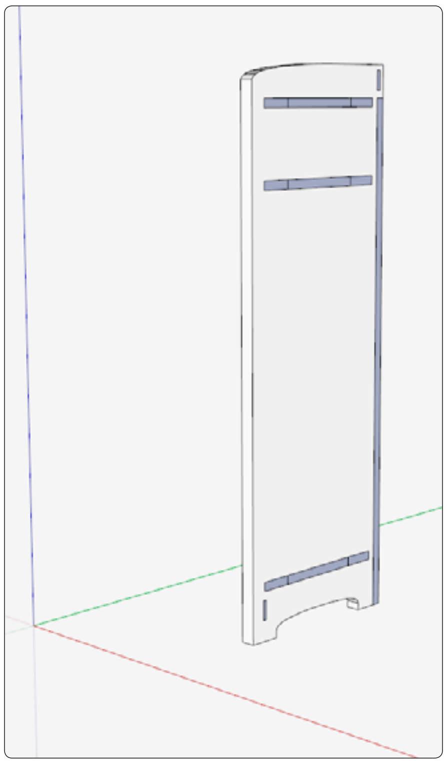


Figure 12. *Use the Push/Pull Tool to give the side component a thickness of 1 in.*

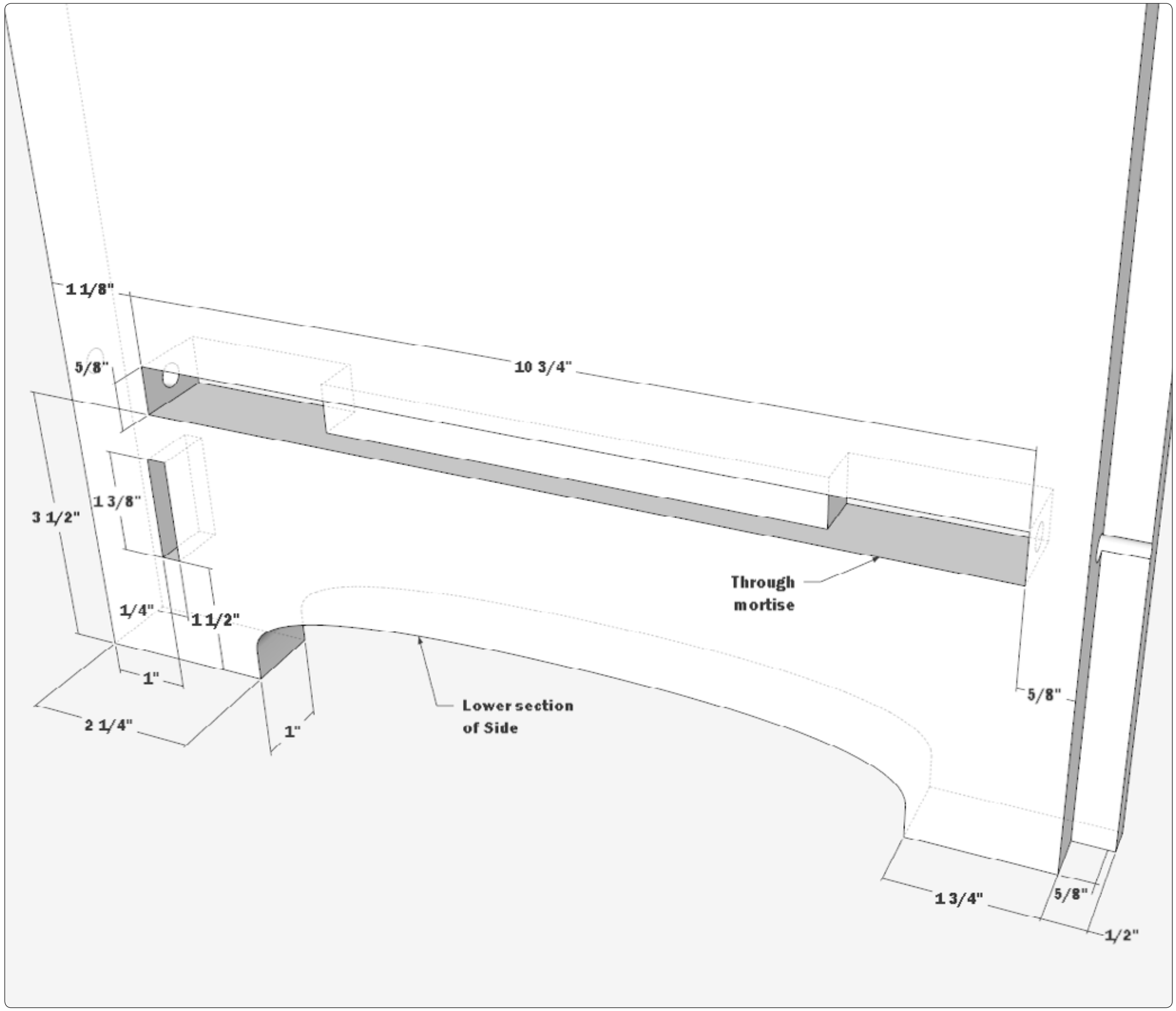
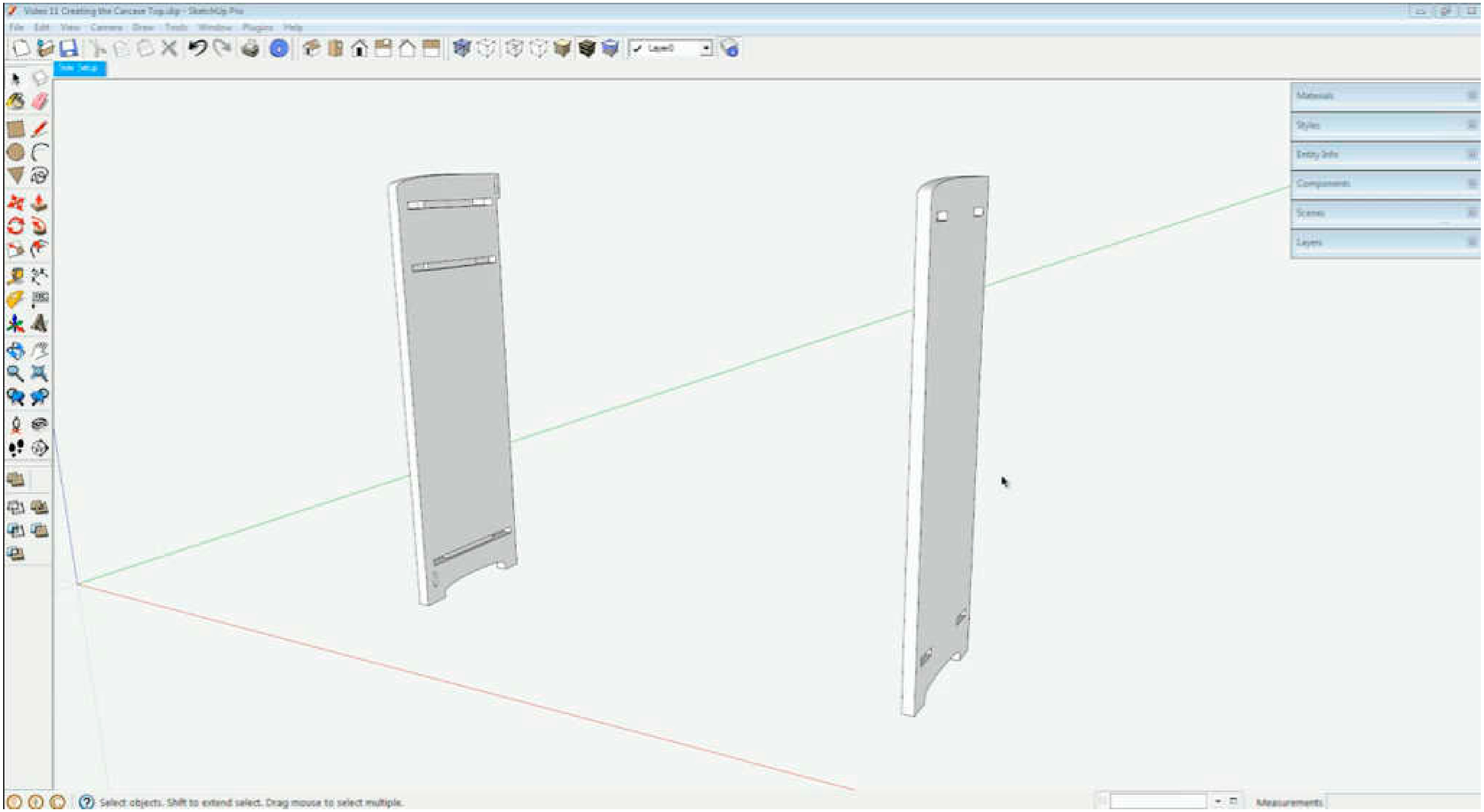


Figure 13. *Dimensions of the mortise location on the lower section of the side.*

Video Tutorial: Creating the Carcase Top

This video shows how to create the cabinet's top component, which connects the two sides. Among other things, the video will show how to use the mortises in the side component to make accurately sized stub tenons and through tenons that connect the top to the carcase sides.



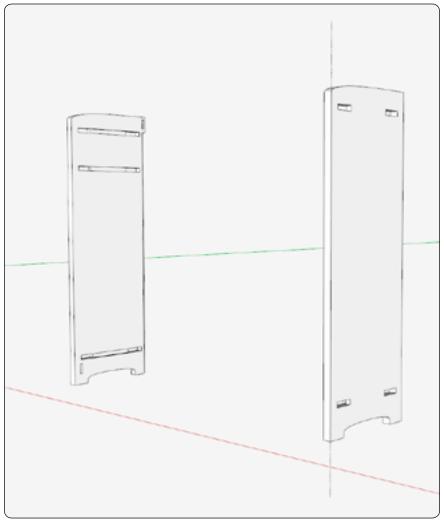


Figure 14. *Copy the side and move it along the red axis. Then do a flip along command.*

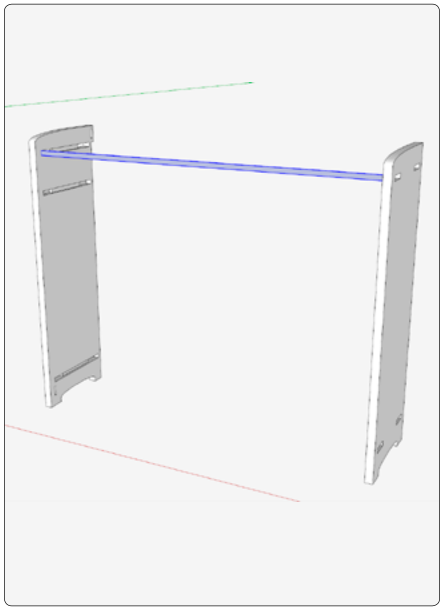


Figure 15. *Draw a rectangle between the sides to begin shaping the top.*

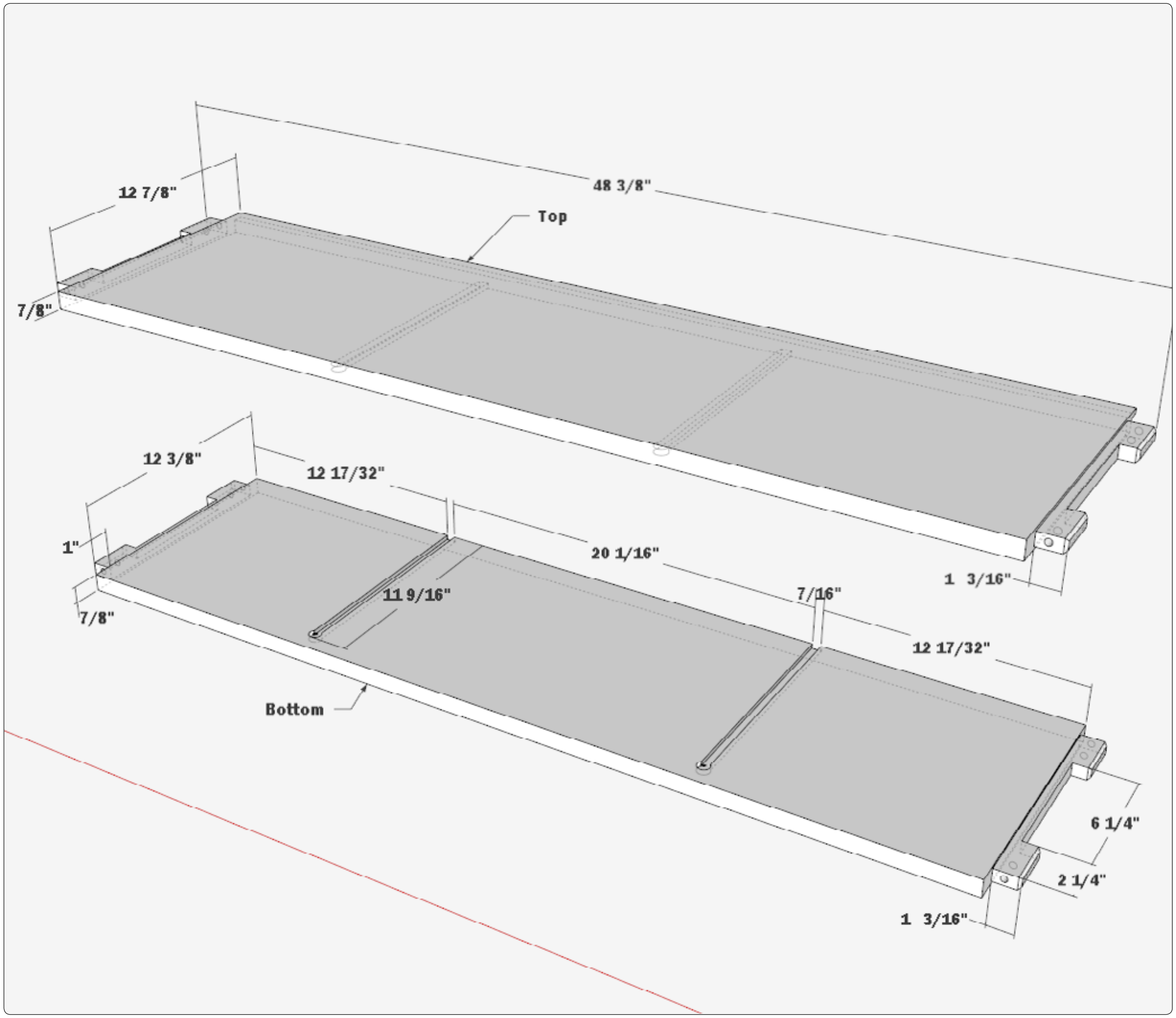


Figure 16. *Dimensions for the top and bottom components.*

Create the Carcase Top and Bottom

This carcase is quite a bit more complicated than the wall cabinet covered in Chapter 3. It has many more internal parts, and they are not all aligned with the front edge of the sides. Instead, these components are inset at various depths, as shown in Figure 2.

Step 7 Place a guideline 48 in. from the outside edge of the side component along the red axis. Copy the side and place it on the guideline so that the overall outside-to-outside measurement is 48 in. Then execute a flip along red axis command to orient the second side properly. See Figure 14.

Step 8 Create the top and bottom components in position between the two sides. Begin with the top. Draw a rectangle at the ends of the topmost mortises in the sides, as shown in Figure 15. Make the rectangle a component.

You could create the top and bottom components separately, using the dimensions shown in Figures 16 and 17. However, I prefer to create model components in position, shaping them in relation to the parts they join and using, say, a mortise to shape a perfectly fitting tenon.

The top is inset from the front edge of the case by ⅛ in. Open the top component for editing. Use the Push/Pull Tool to pull the rectangle face out to the front edge, then push it back ⅛ in. Orbit to the back of the carcase, click on the top component with the Push/Pull Tool, and extend the top to the rear. End the move by clicking the mouse on the back edge of a side. See Figure 18.

Because you used the mortise to begin creating the top, its thickness so far is only

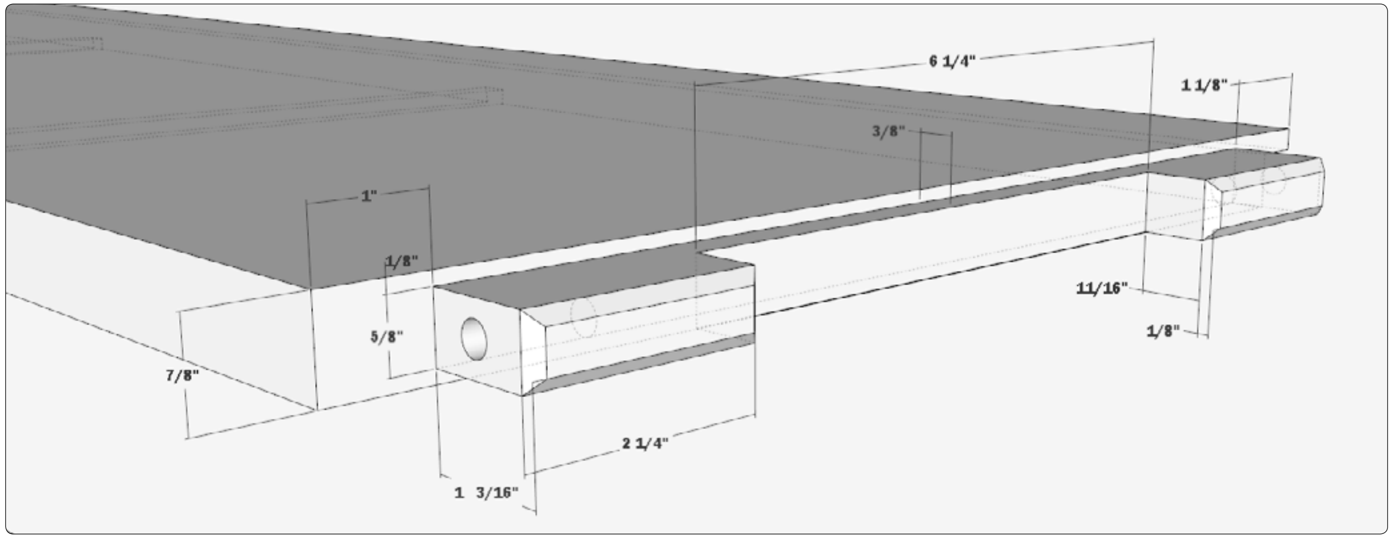


Figure 17. *Detail dimensions for the through tenons on the ends of the top and bottom components.*

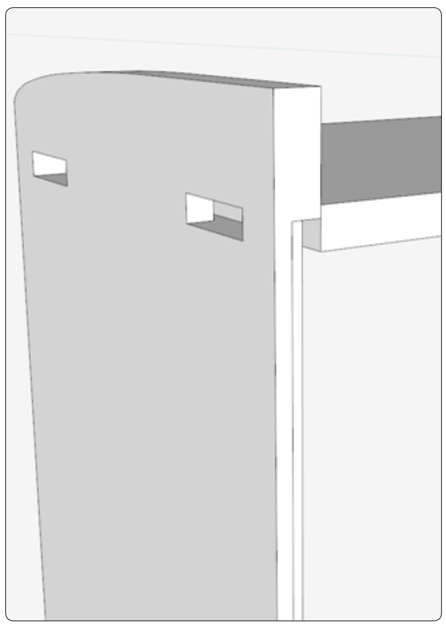


Figure 18. *Rear view showing the top pulled to its full width.*

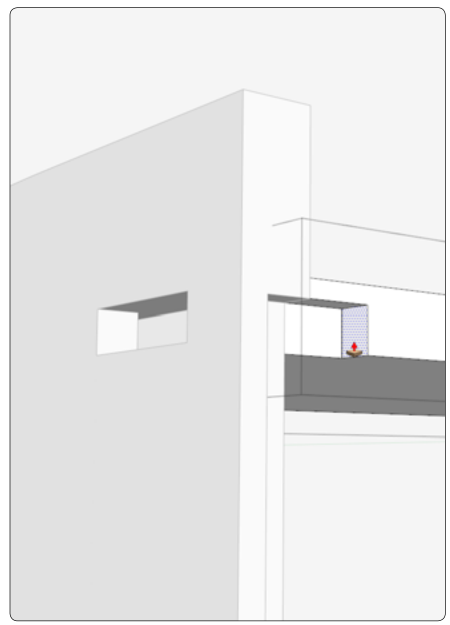


Figure 19. *Create a rabbet in the back edge of the top component.*

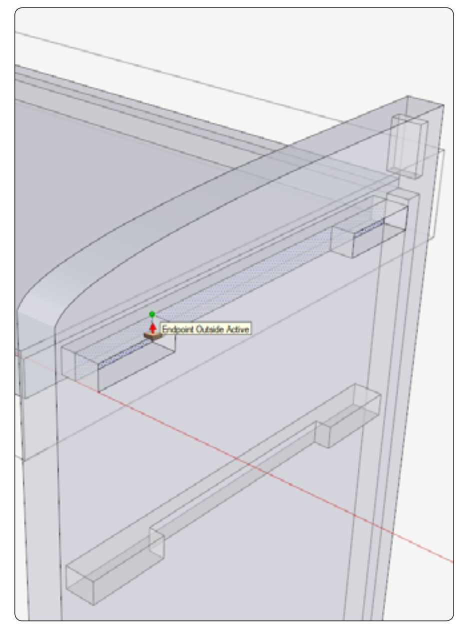


Figure 20. *Trace over the boundary of the mortise and push it to make the tenon.*

⅝ in. To make it the proper ⅞-in. thickness, use the Push/Pull Tool to pull the top and bottom faces up and down by ⅛ in.

Orbit to the rear, as shown in Figure 18. Trace the two edges of the rabbet on the top, then use the Push/Pull Tool to make the rabbet the full length of the back edge. See Figure 19.

Turn on X-Ray, trace the boundary of the rabbet that holds the stub tenon, and use the Push/Pull Tool to push that shape to fill the shallow part of the mortise. See Figure 20.

With the top component still open for editing, trace over the edges of the through mortises. Use the Push/Pull Tool to pull out the tenons until they are flush with the outside edge of the side. Continue pulling until the tenons extend beyond the outer edge of the side by 3⁄16 in. See Figure 21.

Copy the top component and move it away from the assembly. Draw a selection box from left to right over the end of the top, which will highlight the tenons. Copy the selection and move it along the red axis past the opposite end of the top. Execute a flip along command and connect the copied tenons to the end of the top. See Figure 22.

Step 9 Use the top component to make the bottom. The end joinery is identical on both pieces, but the bottom is a different width and has sliding dovetails for the vertical dividers. You'll cut those dovetails in step 13.

Copy the top and move it down along the blue axis to the location of the bottom mortises in the sides. Explode the component and re-make it as the bottom component.

Remove the rabbet and a leftover line on the back edge, as shown in Figure 23.

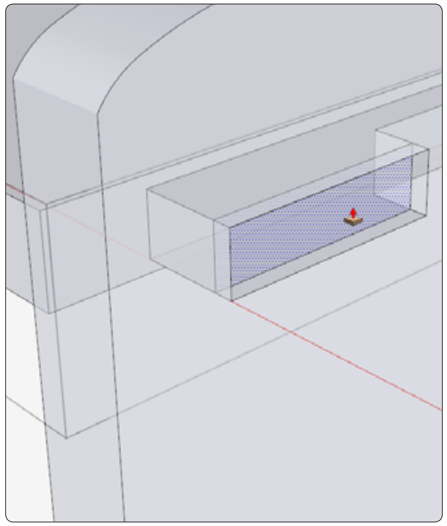


Figure 21. *Extend the through tenon 3⁄16 in. beyond the outside edge of the side.*

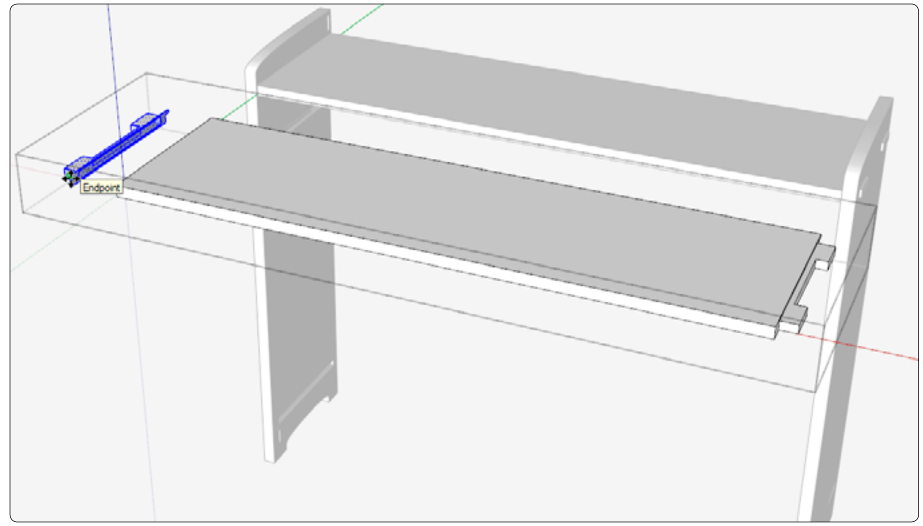


Figure 22. *Copy the tenon joinery to the opposite end of the top component.*

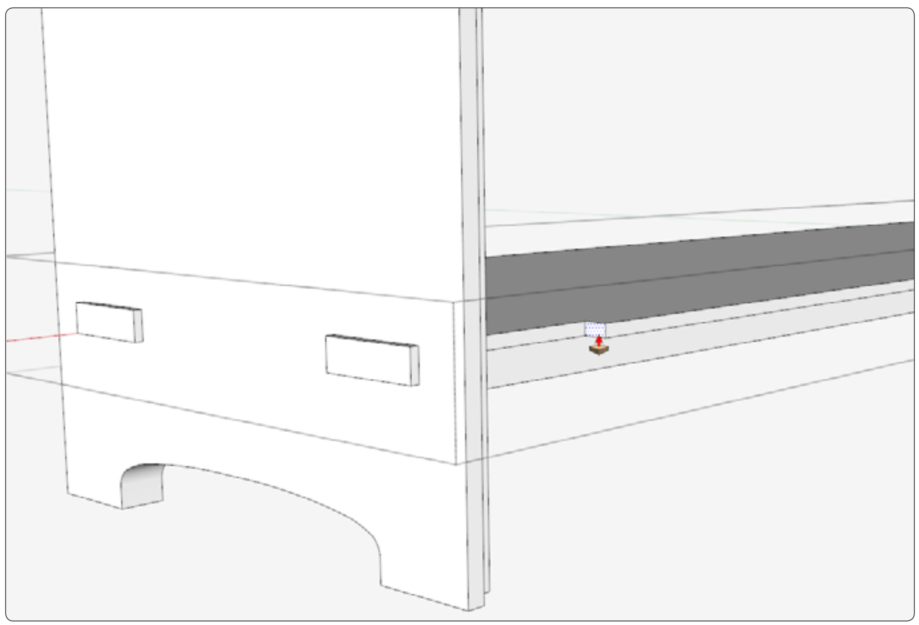


Figure 23. *Remove the lip of the rabbet on the bottom component.*

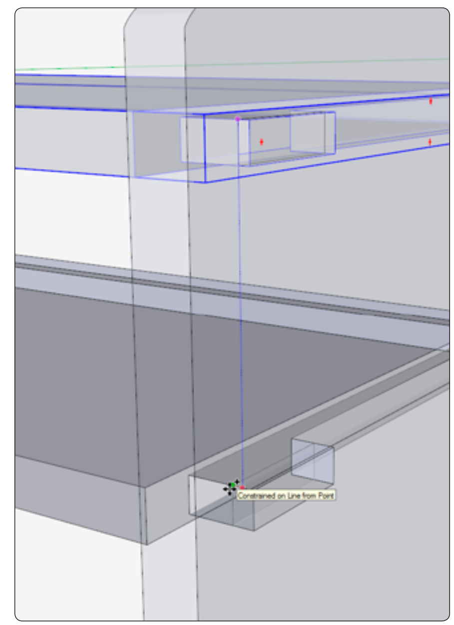


Figure 24. *Move a copy of the top down to create the horizontal divider.*

Step 10 Use the top component to make the horizontal divider. Make another copy of the top and move it down. I used a corner of the tenon as the reference for the move and tapped the down arrow key to constrain the move to the blue axis. It may be easier to position the copy properly if you switch to X-Ray, as shown in Figure 24. Explode the component and re-make it as the horizontal divider component.

The horizontal divider is inset 3⁄16 in. from the case front, so use the Push/Pull Tool to push the front edge in another 1⁄16 in. (it was already inset 1⁄8-in.). The dimensions of this component are shown in Figure 25, but you probably won't need them. Instead, use the existing assembly to trim the size of the component.

Remove the rabbet so that the horizontal divider's back edge is flush with the bottom of the rabbet in the sides.

Next, change the thickness of this component from 7⁄8 in. to 3⁄4 in. Use the Push/Pull Tool to remove 1⁄16 in. from the top and bottom faces.

The horizontal divider does not have through tenons. In X-Ray view, use the Push/Pull Tool to shorten the tenons to the depth of the side mortises. See Figure 26. Do the same for the tenons on the opposite end of the component.

Step 11 Now that the horizontal parts are installed, you can create the vertical dividers. Figures 27 and 30 give their overall dimensions. Figure 28 shows the detail dimensions of the sliding dovetail joint on the edge of the dividers. I've drawn the dovetail to match the 1⁄2-in. by 14-degree router bit that Pekovich used. Of course, you can

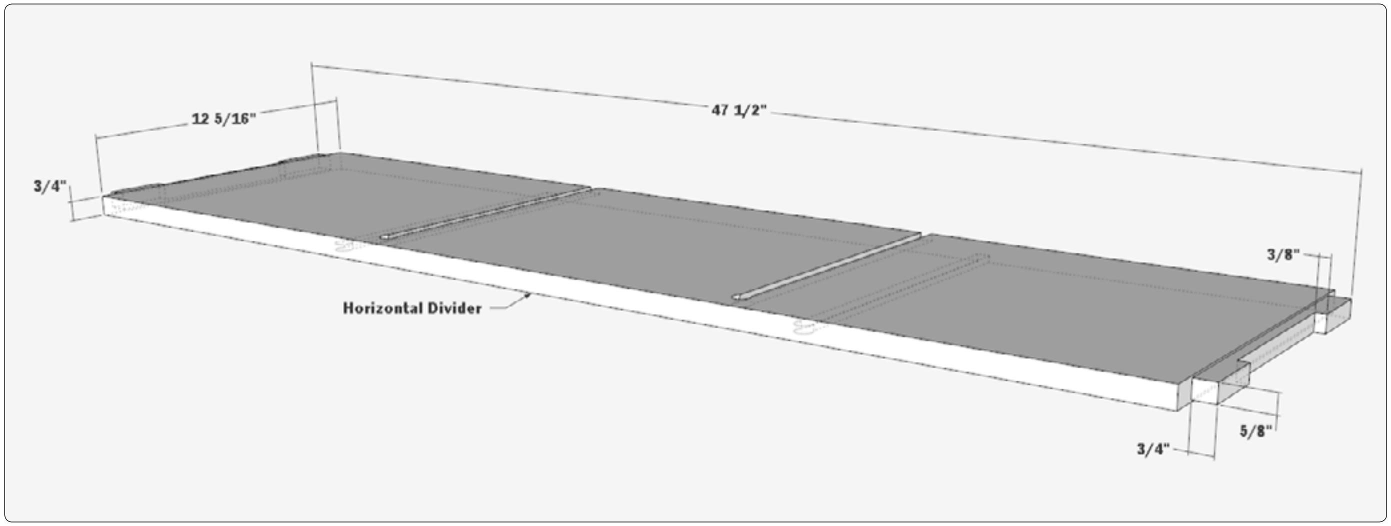


Figure 25. *Dimensions of the horizontal divider. Use them to check your work if necessary.*

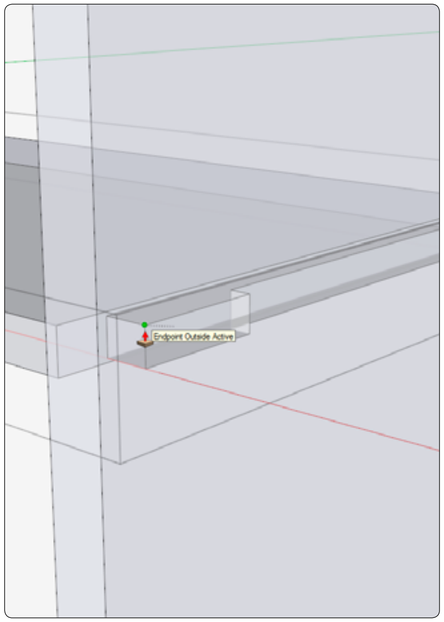


Figure 26. *Shorten the tenons on the divider to match the depth of the mortises.*

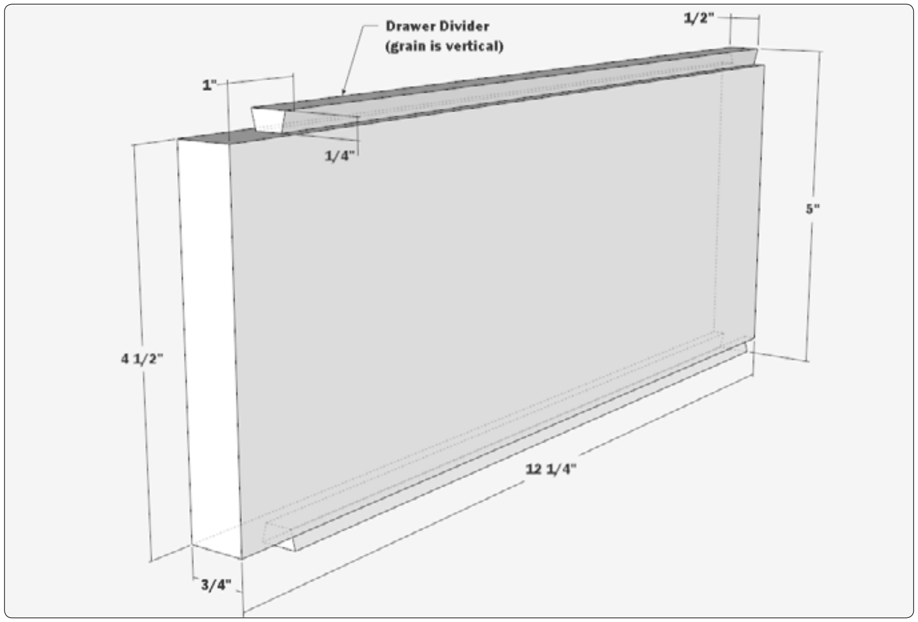


Figure 27. *Dimensions of the drawer divider. In the shop, orient this piece so its grain is vertical. That way, it will move consistently with the other components in the carcase.*

modify the drawing as needed to match the router bit you plan to use.

For the drawer divider, begin by creating a rectangular face 12¼ in. wide and 5 in. long, on the blue-green plane away from the carcase. Make the face ¾ in. thick, as shown in Figure 27, and make it a component.

Using the Tape Measure and Protractor Tools, place guidelines to define the shape of the dovetail on the top and bottom edges of the drawer divider. See Figures 28 and 29. Trace over the outline of the dovetail shape, then remove the waste with the Push/Pull Tool, as shown in Figure 29. Draw a line at the base of the dovetail shape on the front edge, then push back the dovetail shape until it is 1 in. from the front edge.

Step 12 Follow the procedures in Step 11 to create the vertical divider. Use the dimensions given in Figure 30. The sliding dovetails are identical to those on the drawer divider. You can add the shelf pin holes as shown in Figure 30; they are ⁵⁄₁₆ in. in diameter and ½ in. deep. I think it is helpful in the shop to have the centers of holes shown on the drawings. To do that, right-click on the circle and choose Point at Center from the pop-up menu.

Step 13 Place the dividers into the carcase assembly. I think that is easier to do from the rear of the carcase, since the back edges of the dividers are flush with the back edge of the horizontal divider and the bottom. The dividers should be inset ¼ in. from the front edge of the case. Place guidelines from the inside face of the side to help position the dividers. Figure 31 shows the distance from the side to the dividers.

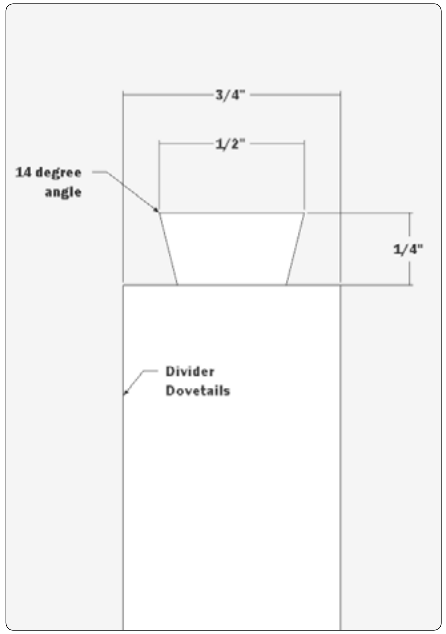


Figure 28. *Divider dovetail details.*

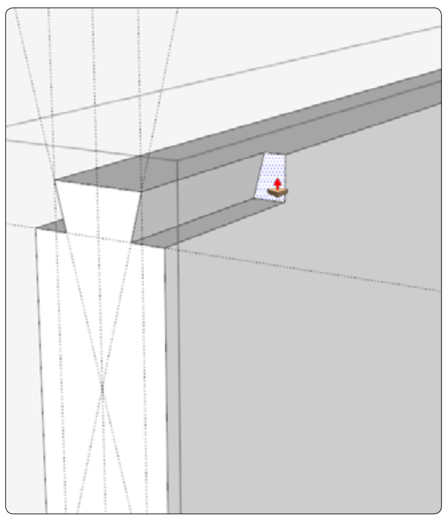


Figure 29. *Place guidelines, trace the shape of the dovetail, then remove the waste.*

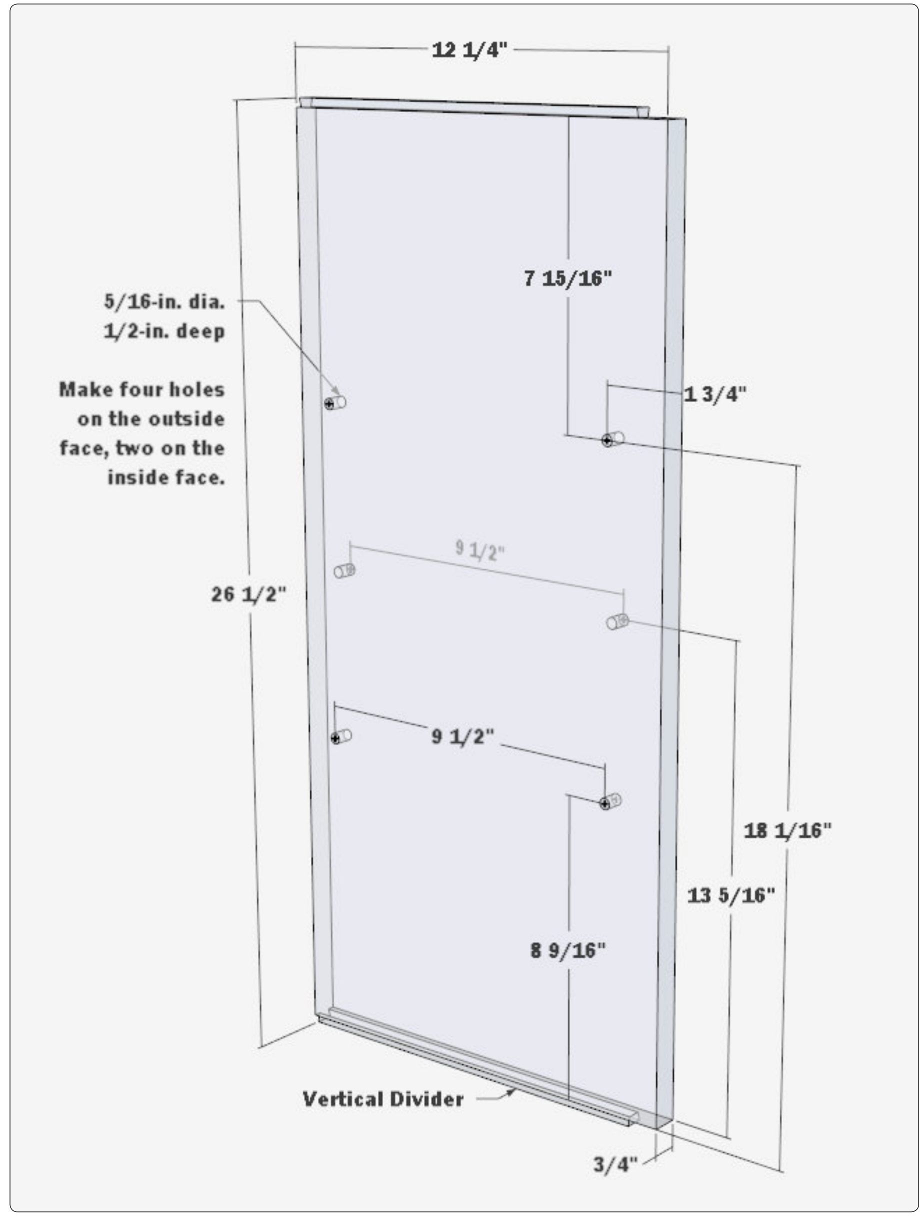


Figure 30. *Dimensions of the vertical divider, in X-Ray view to show locations for the shelf-pin holes on both sides of the component.*

Copy the dividers, move them to the back side of the carcase, and do a flip along component's red command. This orients the shelf-support holes properly. See Figure 32.

Create the sliding dovetail grooves in the top, horizontal divider, and base. Open the top component for editing and trace over the shape of the dovetail on the back edge of the top. Place a guideline 1 in. back from the front edge of the divider. Use the Push/Pull Tool to push out the sliding dovetail, stopping it on the guideline.

Repeat for the remaining dovetails in the other horizontal pieces. The horizontal divider has dovetail grooves on its top and bottom faces.

Step 14 Aside from the removable shelves, there are four more pieces required to complete the carcase: the front and rear apron, the backsplash, and the back. The front apron and backsplash are similar, connected to the carcase sides with mortise-and-tenon joints.

To make the rear apron, draw a rectangle between the sides and below the bottom, as shown in Figure 33. Make the rectangle a component.

Using the dimensions shown in Figure 36, place guidelines and shape the cutout on the rear apron. See Figure 34. After deleting the waste, use the Push/Pull Tool to pull the thickness to be flush with the back edge of the side. See Figure 35. You will see gaps at the ends equal to the depth of the rabbet in the sides. Draw a line on the apron along the edge of the side. Then pull out the ends flush with the bottom face of the rabbets.

The rear apron is ⅞ in. thick. Orbit around so you can see the inside face of the apron.

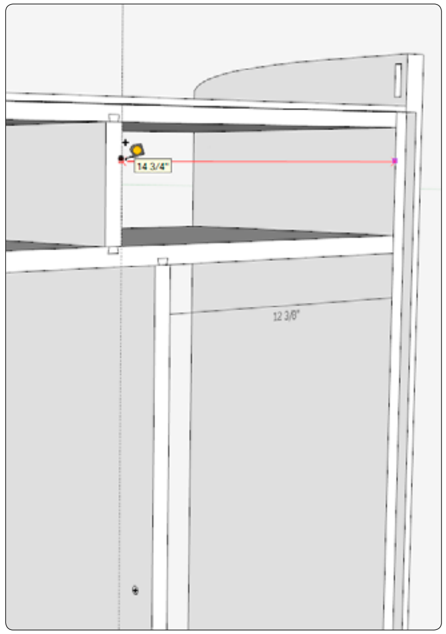


Figure 31. *Positioning the dividers in the carcase assembly.*

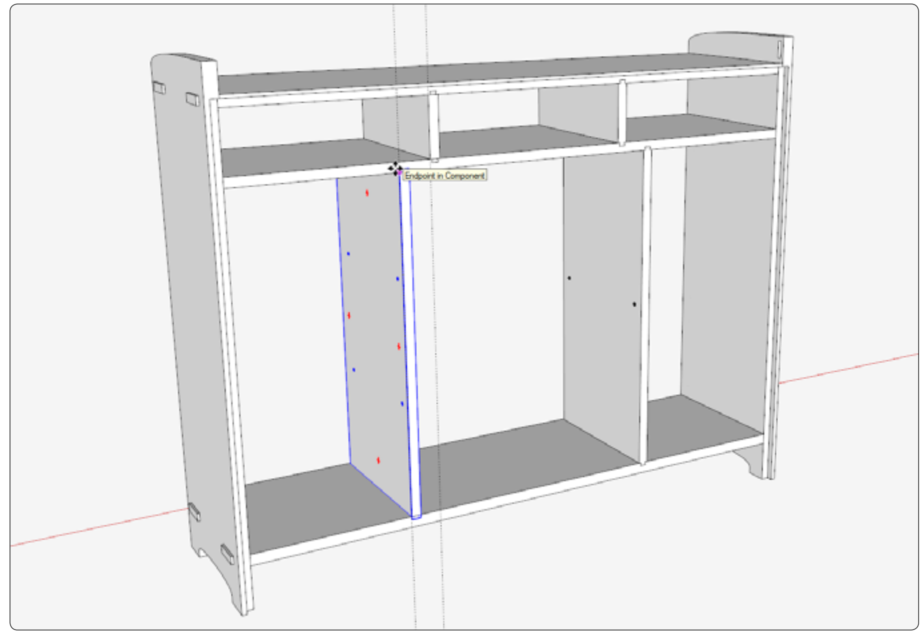


Figure 32. *Copy the dividers and flip them along the red axis. Use the dovetail shape on the dividers to create the matching grooves in the horizontal pieces.*

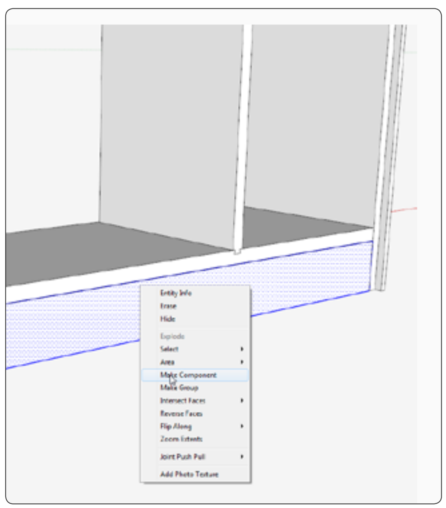


Figure 33. *Draw a rectangle in the lower back opening and make it a component.*

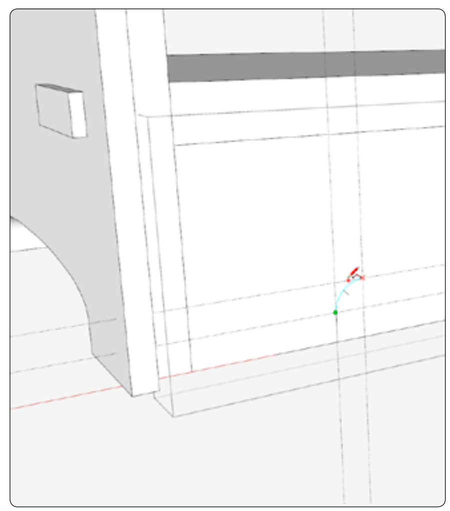


Figure 34. *Shape the cutout in the lower edge of the rear apron.*

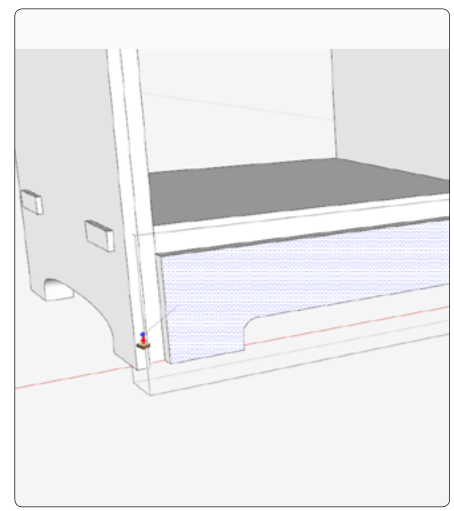


Figure 35. *Make the apron ½ in. thick and flush with the back edge of the carcase.*

Highlight the face, then use the Push/Pull Tool to pull the face out ⅜ in. See Figure 37.

Step 15 Add the front apron next. It is sized to be 1 in. off the floor and inset 11⁄16 in. from the front edge of the side. You can see it in position in Figure 1.

Begin by drawing a guideline 11⁄16 in. from the front edge of the side and another 1 in. off the floor. Draw a ⅞-in.-thick rectangle for the end shape of the apron. Make the rectangle a component and pull it to length, ending at the opposite side. See Figure 38. Make the apron a component.

Use the mortises in the side components to shape the tenons in the front apron. Switch to X-Ray view and open the apron for editing. Orbit around so you are looking through the side. Use the Line Tool to trace over the end of the mortise in the side. This creates the end of the tenon. Use the Push/Pull Tool to lengthen the end until it touches the apron.

You can use the same procedure to create the tenon on the other end of the Apron. Or, make a copy of the tenon, move to the opposite end of the apron, execute a flip along command, and connect it to the apron.

Step 16 Construct the backsplash much the way you did the front apron and connect it to the sides with mortise-and-tenon joints. The back of the backsplash is flush with the back edge of the side. The top edge of the backsplash rises above the top of the sides by ⅜ in., and the upper corners are rounded. See Figure 36 for dimensions.

Draw a rectangle for the back face of the backsplash and make it a component. Use the Circle or Arc Tool to round over the

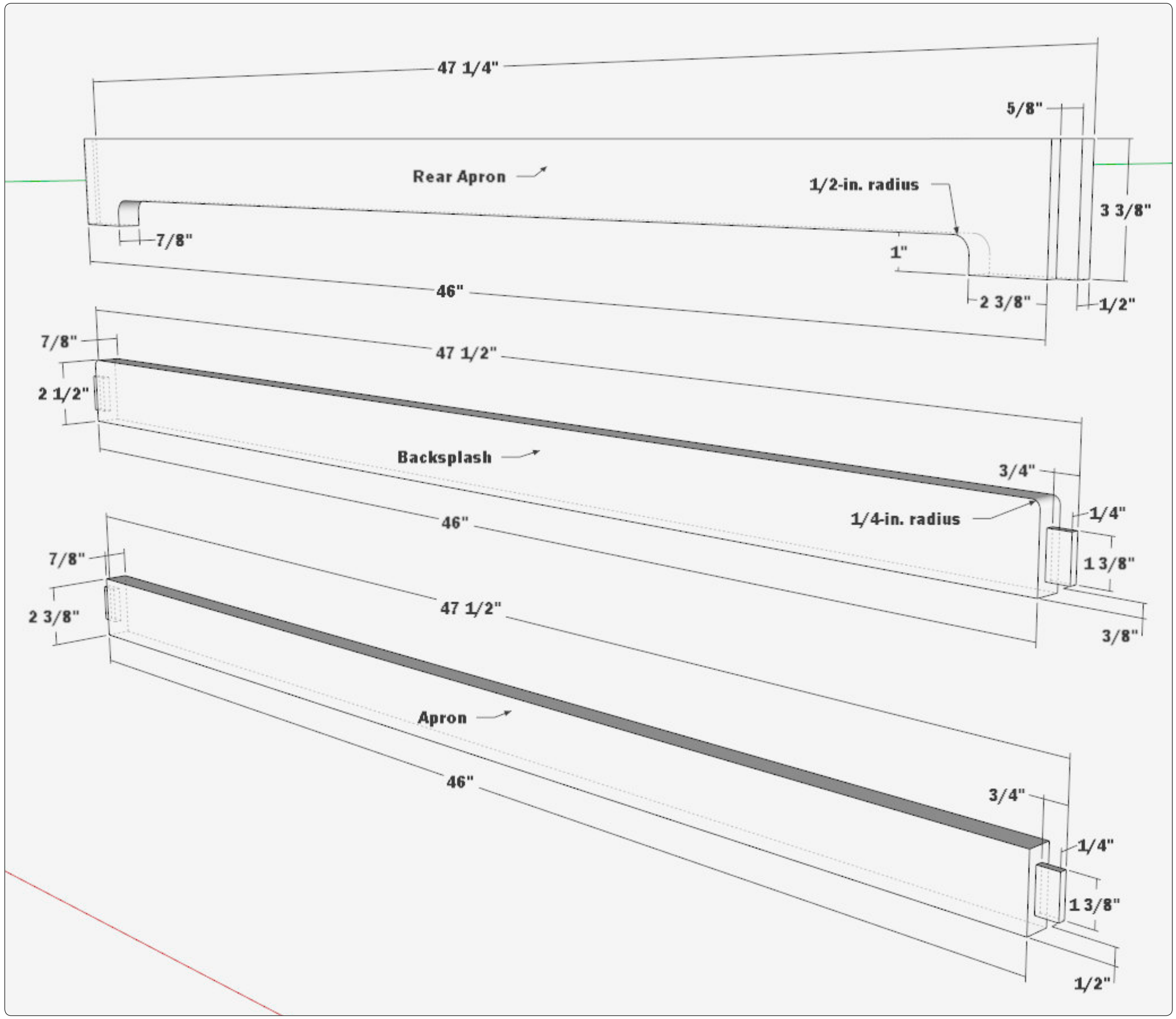


Figure 36. *Dimensions and joinery details for the front and rear apron and the backsplash. Use the dimensions as a check. In most instances, you can draw these components in position and use mating pieces to size the joinery.*

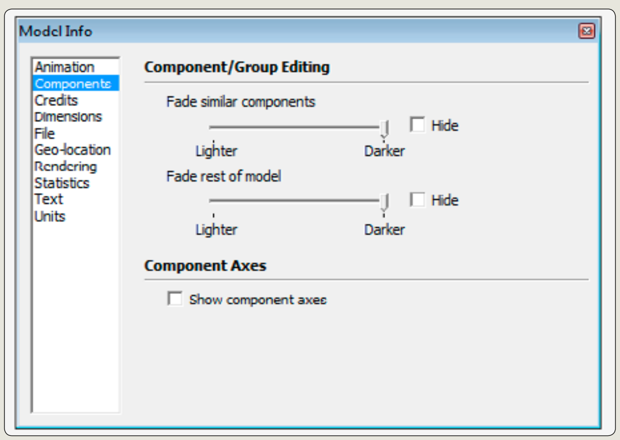
upper corners, then make the component 7/8 in. thick. Create the tenons as you did on the front apron, following the procedures in Step 15.

Step 17 The removable shelves are shown, with dimensions, in Figure 40. They are easy to make in SketchUp because they are simple rectangular parts. They have grooves in the ends for the supporting shelf pins. Pekovich uses pins that are 5/16 in. in diameter and 1-in. long. The flat-bottomed grooves, 1/4 in. deep and 5/16 in. wide, are easy to make with the Push/Pull Tool. In the shop, it's critical to cut these grooves precisely, so that they mate properly with the pins in the sides and vertical dividers. The dimensions given for the pin holes and shelf grooves are shown center-to-center to help you fit pin to groove correctly.

How to Make Lines More Visible

When you open a component for editing, SketchUp automatically grays out all other components in the view. There are times, however, when you want to see those grayed-out edges to make it easier to add elements accurately. For example, when shaping a tenon, it is advantageous to use the corresponding mortise as a template. But that can be frustrating if you can't see the boundaries of the mortise.

SketchUp provides a way to adjust the amount of graying out. Click on the Window tab and select Model Info from the pop-up menu. In the left-hand panel of the Model Info dialog box (see image below), click on Components. This opens a dialog box with two slider bars at the top. You can adjust the sliders all the way to the Darker setting. This will eliminate the graying out and help you see whatever edges you need to see.



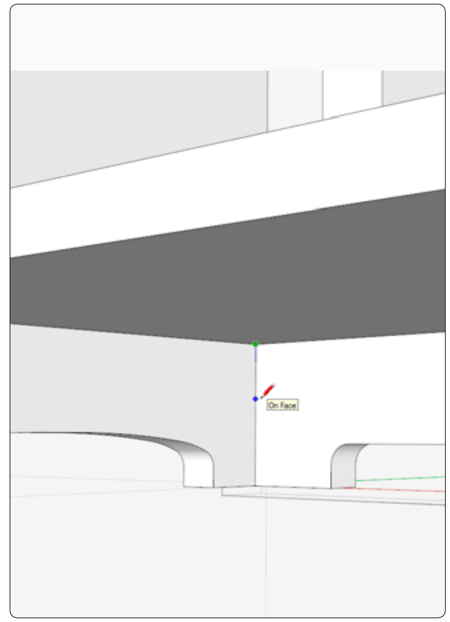


Figure 37. *Draw a line on the corner intersection before pulling out the rear apron.*

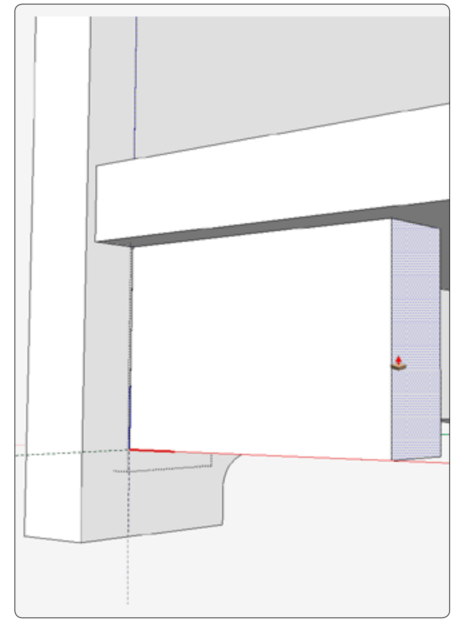


Figure 38. *Draw a rectangle for the end shape of the apron, then pull it to length.*

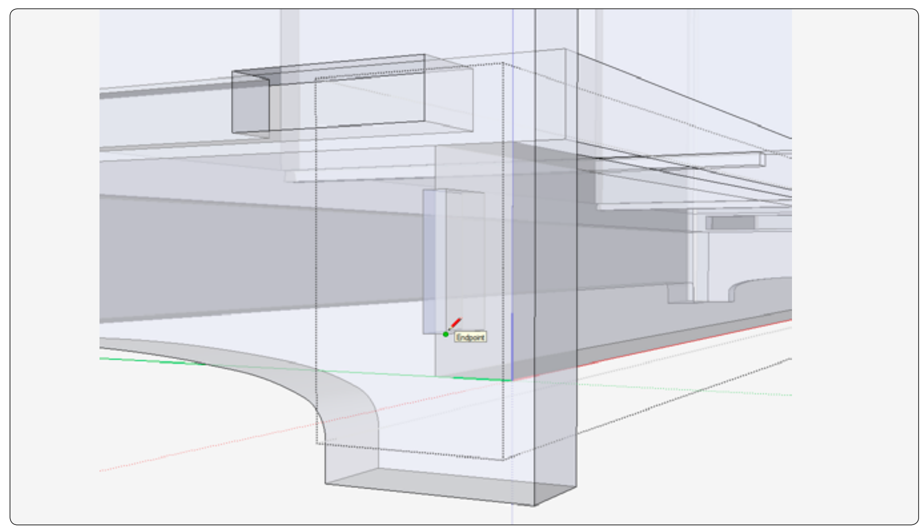


Figure 39. *Draw lines around the base of the mortise, then push the tenon until it touches the edge of the apron.*

Step 18 The through tenons on the top and bottom components are pinned into the sides front and back. Pekovich uses pins that are 5⁄16 in. in diameter and 2 in. long.

As shown in Figure 40, place guidelines to locate the center of the tenon pin. Draw a circle that is 5⁄16 in. in diameter (or with a radius of 5⁄32 in.) Then use the Push/Pull Tool to push in the hole to the mortise opening. Repeat this for the other seven pin locations.

Typically, I don't add a pin hole to tenons in a SketchUp model. That extra hole doesn't help me in the shop because I drill the hole for the pin with the joinery clamped. All I need is the center for the hole on the outside edges of the sides.

Step 19 The through tenons have a 1⁄8-in. chamfer on their protruding ends. There are several ways to add that detail, including using the Follow Me Tool. But I think there is an easier way, as shown in the four steps of Figure 42. Use the Push/Pull Tool to push back the tenon length by 1⁄8 in., leaving a 1⁄16-in. protrusion. Use the Offset Tool to create a rectangular border 1⁄8 in. from the edge. Now, with the Line Tool, connect the corners of the offset and the outer corners. Finally, use the Move/Copy Tool to pull out the inner rectangle by 1⁄8 in.

Step 20 The back panel is the last component needed for the carcase. In this case the panel consists of shiplapped boards, multiple pieces with overlapping joints along their length. This type of construction accommodates expansion and contraction of the panel with weather changes.

Designing a shiplapped back panel is a somewhat iterative process. The critical

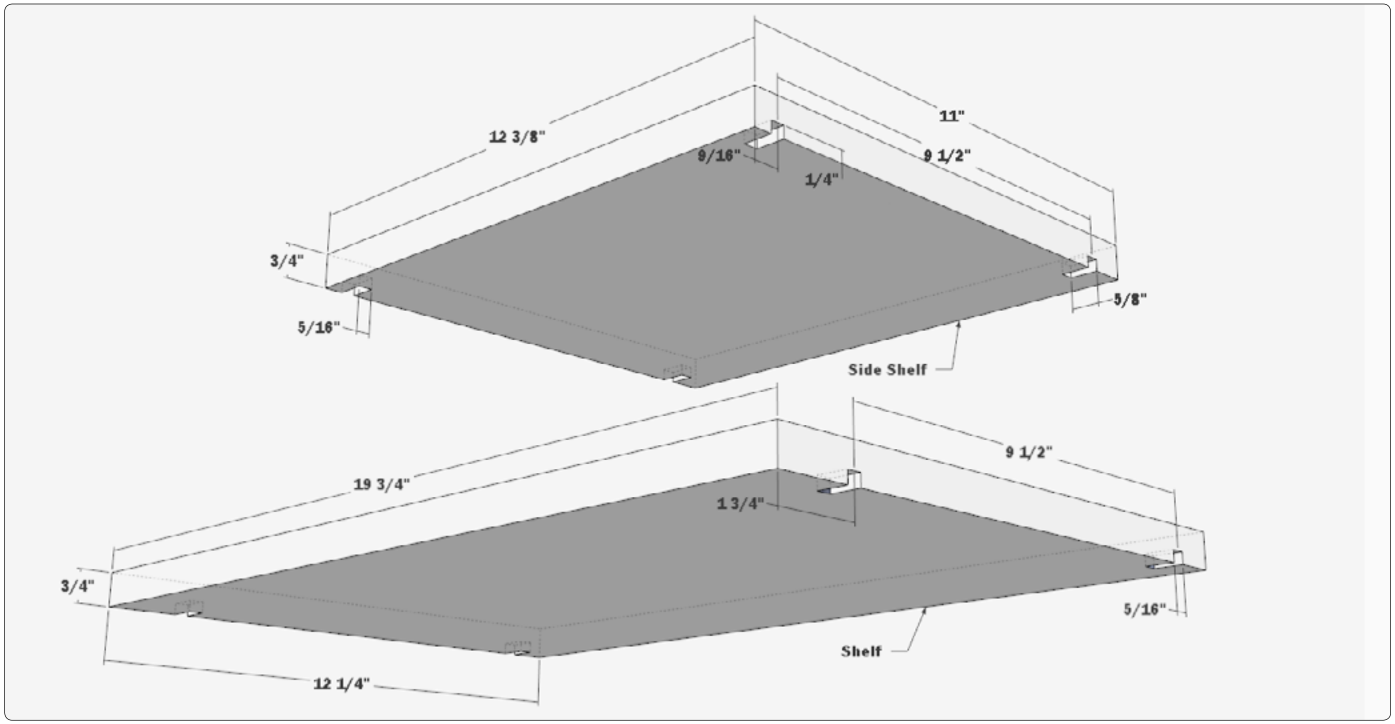


Figure 40. A view looking up to the bottom faces of the shelves, with overall dimensions and sizes for the grooves that hold support pins.

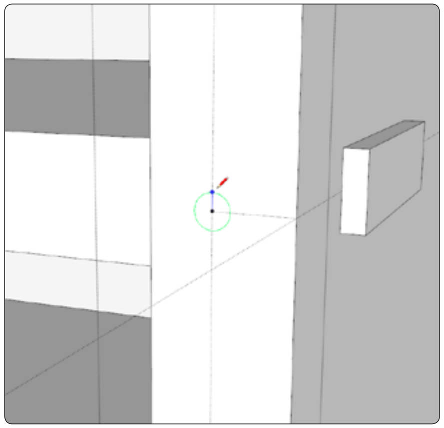


Figure 41. Draw a circle for the tenon pin location. Then push in to the tenon.

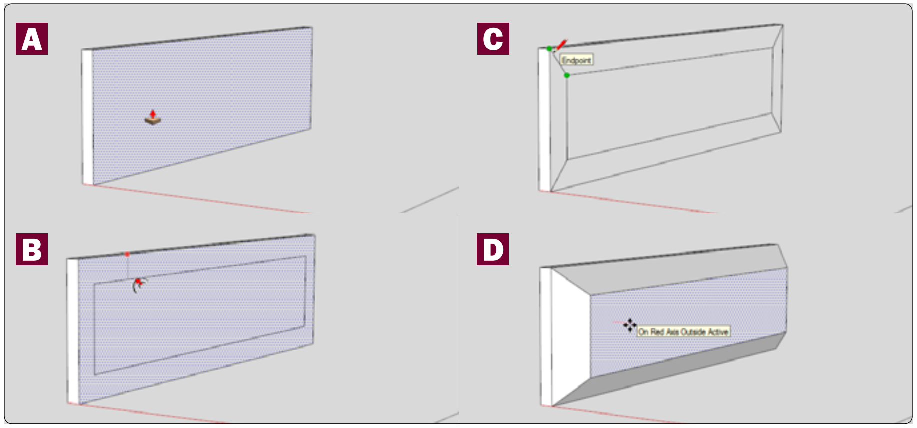


Figure 42. Step A: Push in the front face 1⁄8 in. Step B: Use the Offset Tool to draw a second shape 1⁄8 in. from the edge. Step C: Add lines at the corners. Step D: Pull out inner shape 1⁄8 in.

parameters are the width of the slats, the amount of overlap in the joint, and the expansion gap between the slats. These factors determine the number of slats needed to fill the open space in the back of the carcase.

The slats do not have to be the same width. I often use whatever I have on hand in the shop, so the number of slats and their widths may not follow the initial design. It's more important to have an established design for the shiplap joint, including the expansion gap. You can then mill stock, organizing the pieces as you go, until you have filled the required space.

In this cabinet, the back panel is a visual part of the middle open section. Pekovich specifies equal widths for all slats except the two at either end. They can be trimmed as needed to fill the space. Figure 43 gives the necessary dimensions.

Figure 45 shows the lap joint on the ends of the slats (the two end slats have a lap joint on only one edge). The edge that fits flush in the case rabbet has no lap joint.

Create two slat components in SketchUp, one for the seven middle slats and another for the end slats. These parts are quickly created with the Line Tool and the Push/Pull Tool. See Figures 44 and 45. When you place the slats in the carcase, note that they are inset ⅛ in. into the rabbet in the top and side components.

Back Slat Math

Figure 45 shows the detail of a shiplap joint. The rabbet for the lap is ⅜ in. long and half the depth of the slat. I typically use an air gap of 1⁄16 in., so the slats overlap by 5⁄16 in. at each end. This means that the effective width of the slat is 5⁄16 in. less than its actual width. Suppose I decide to make slats with an actual width of 5½ in., based on the material I have on hand in the shop. Here's how I determine the number of slats needed. Reduce the actual width by 5⁄16 in. (the overlap in one end joint) to get an effective width of 5 3⁄16 in. The opening in the cabinet is 47¼ in. wide. Divide 5 3⁄16 into 47¼ to determne the approximate number of back slats. The result is 9.1 slats. Rounding down, that means making 9 slats at 5½ in. wide, with the end slats wider to take up the slack. There is no air gap at the outside ends of the end slats. They butt up against the rabbet in the sides.

For more precision in determining the number of slats required, you can use the following formula. (I'll admit that it was fun deriving this formula, but I see no reason to ever use it.) The amount of air gap is not a factor.

n=(L−lap)/(W−lap) where n is the number of slats

L is the opening width in the back of the carcase

W is the desired width of all slats

lap is the overlapping distance in the shiplap joint

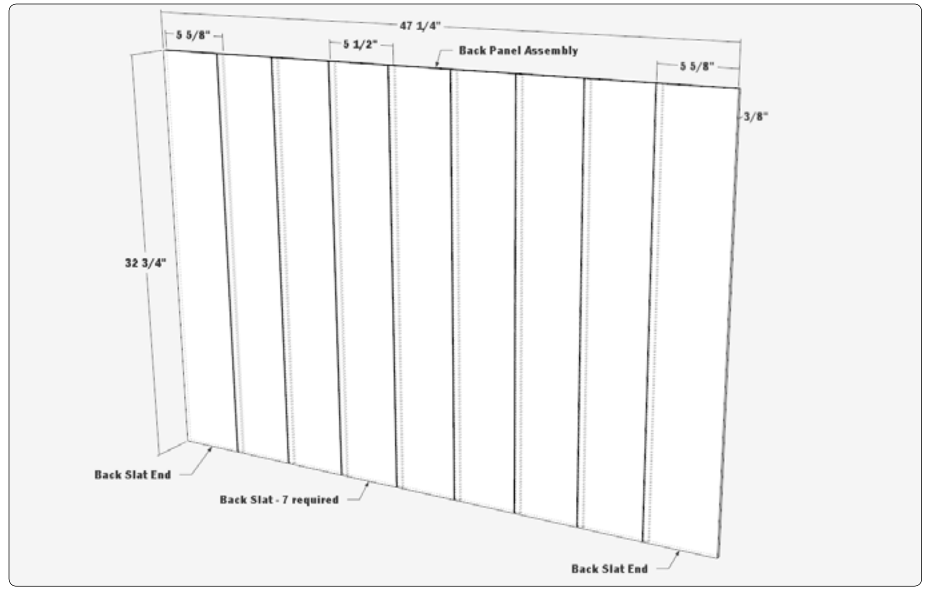


Figure 43. *The overall dimensions for the back panel. Most pieces are 5½ in. wide. The two end pieces are wider, to fill the space in the carcase.*

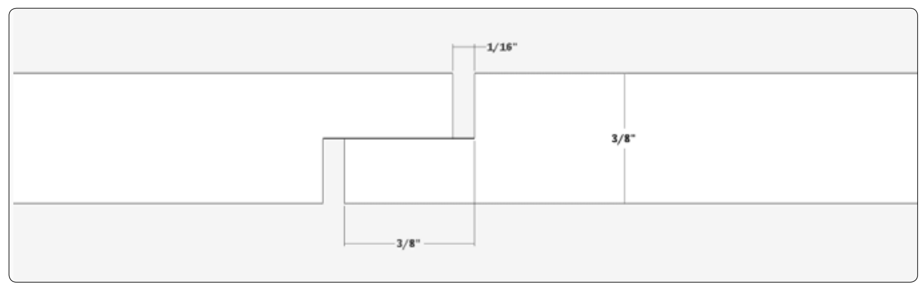


Figure 44. *The shiplap joint. The air gap between boards is 1⁄16 in., the overlap, 5⁄16 in.*

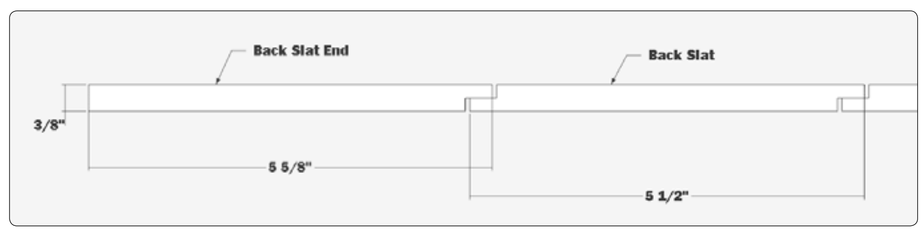


Figure 45. *As this top view shows, the end slats have a tongue on only one edge, while the others have tongues on both edges.*

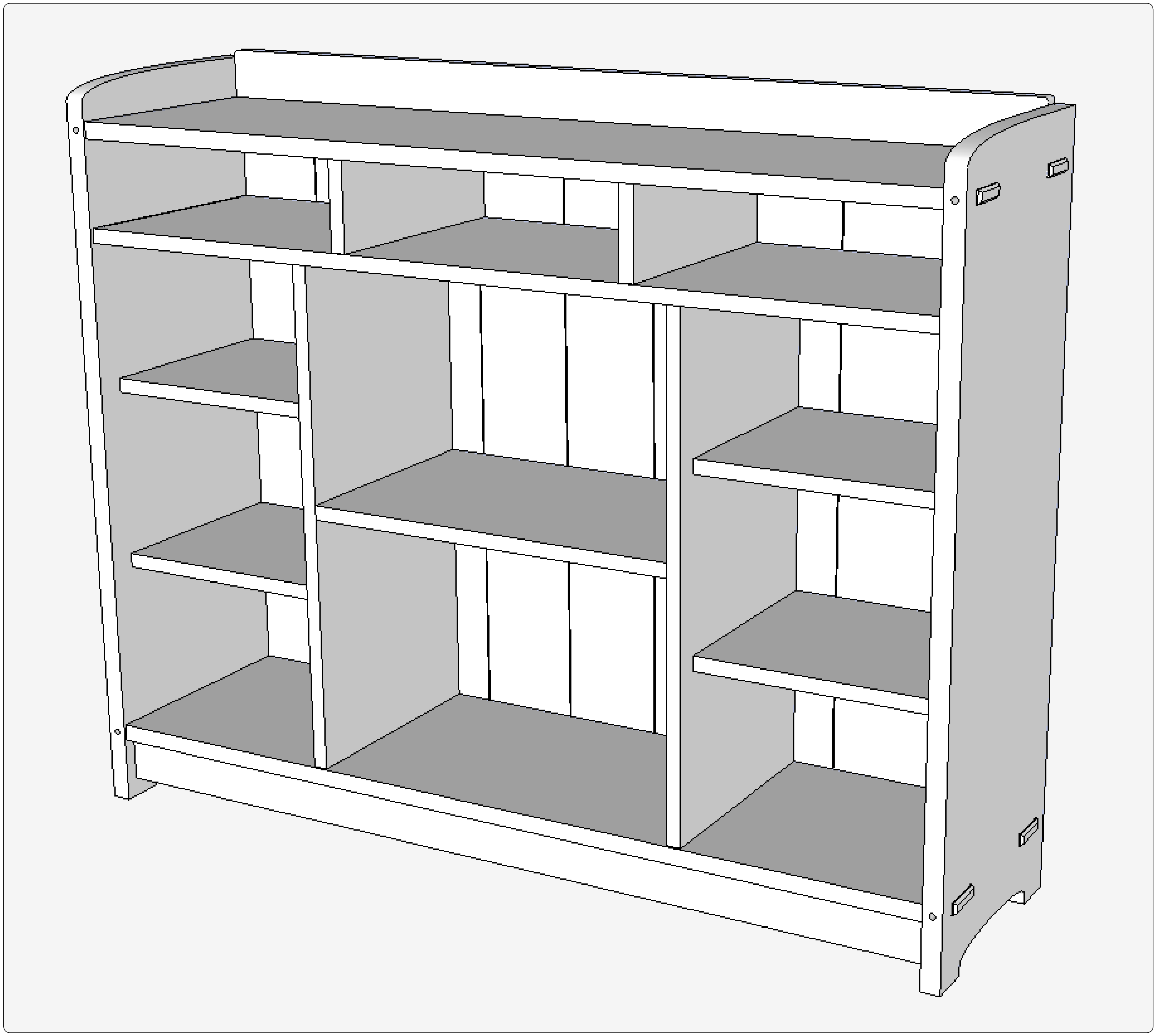


Figure 46. *A simple look, but in truth, a sophisticated construction.*

Status Report

This case looks deceptively simple. In reality however, it is a complex carcase.

First, it contains more parts than you would expect, and they have different thicknesses. Many of these parts are connected with sophisticated joinery, such as sliding dovetails or pinned through tenons. And then there are the stub tenons. Nothing simple here.

Also, the positioning of parts inside the cabinet is not intuitive. In most cabinets I've built, internal parts are located flush with the front edge. Each part has a unique inset from the front edge of the cabinet.

You would expect removable shelves to be a piece of cake. But in this case, they are held in place with hidden support pins requiring accurately spaced holes and grooves.

I'm getting a feel for the weight of this piece. There is quite a bit of lumber here and it is heavy oak. Even without contents, this will take some effort to move around the house.

Creating the Cabinet Door

Doors this size usually have rails and stiles made from ¾-in.-thick material. In this case, however, the door frame is ⅞ in. thick to accommodate the leaded glass assembly that sits in a rabbet in the back of the door frame. Pekovich explains how to make the leaded glass assembly in companion article to the one about making the case.

Figure 47 shows two of the metal frame pieces that capture the glass panes. Lead pieces known as "came" have an H-shaped cross-section so they can hold the individual glass pieces in a ladder-type structure. I've named it the lead came frame. Around this structure is a soldered frame of zinc U-channel. This package of glass and metal rests in a rabbet in the back of the door frame. Stops overlay the glass frame and are fastened to the rabbet. See Figure 49.

Structurally, the doors are a conventional stile-and-rail design, assembled with mortise-and-tenon joints.

There is one more unusual aspect to the door construction, however. The door is inset from the front of the carcase, so a ¼-in.-thick hinge strip must be attached to the sides of the carcase. See Figure 50. Before you begin modeling the door, create the hinge strips and place them in the carcase,

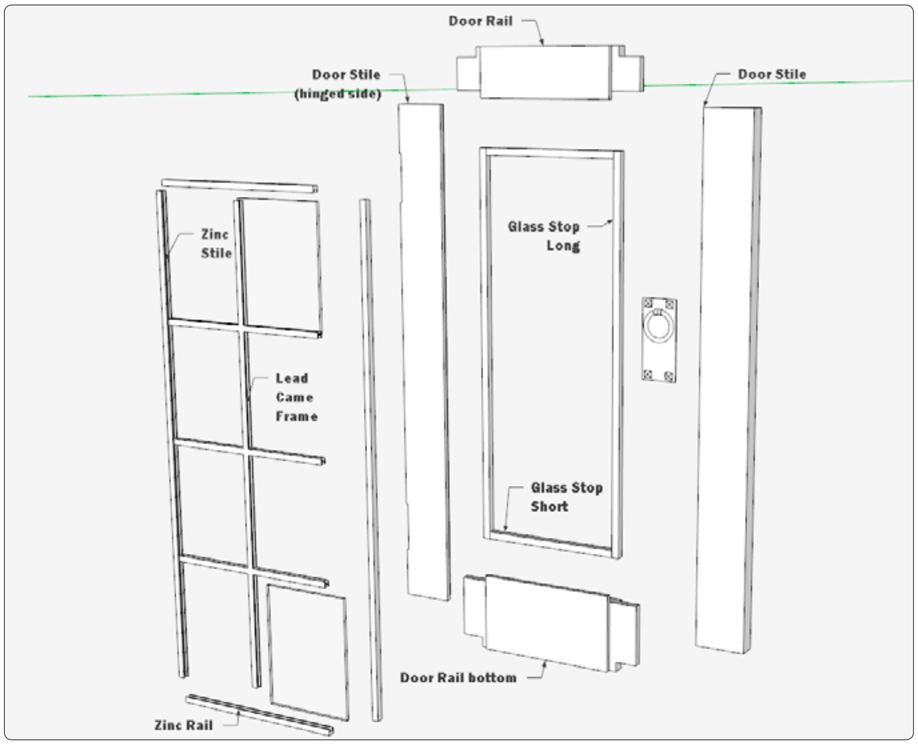


Figure 47. *An exploded view of the door frame and the leaded-glass assembly.*

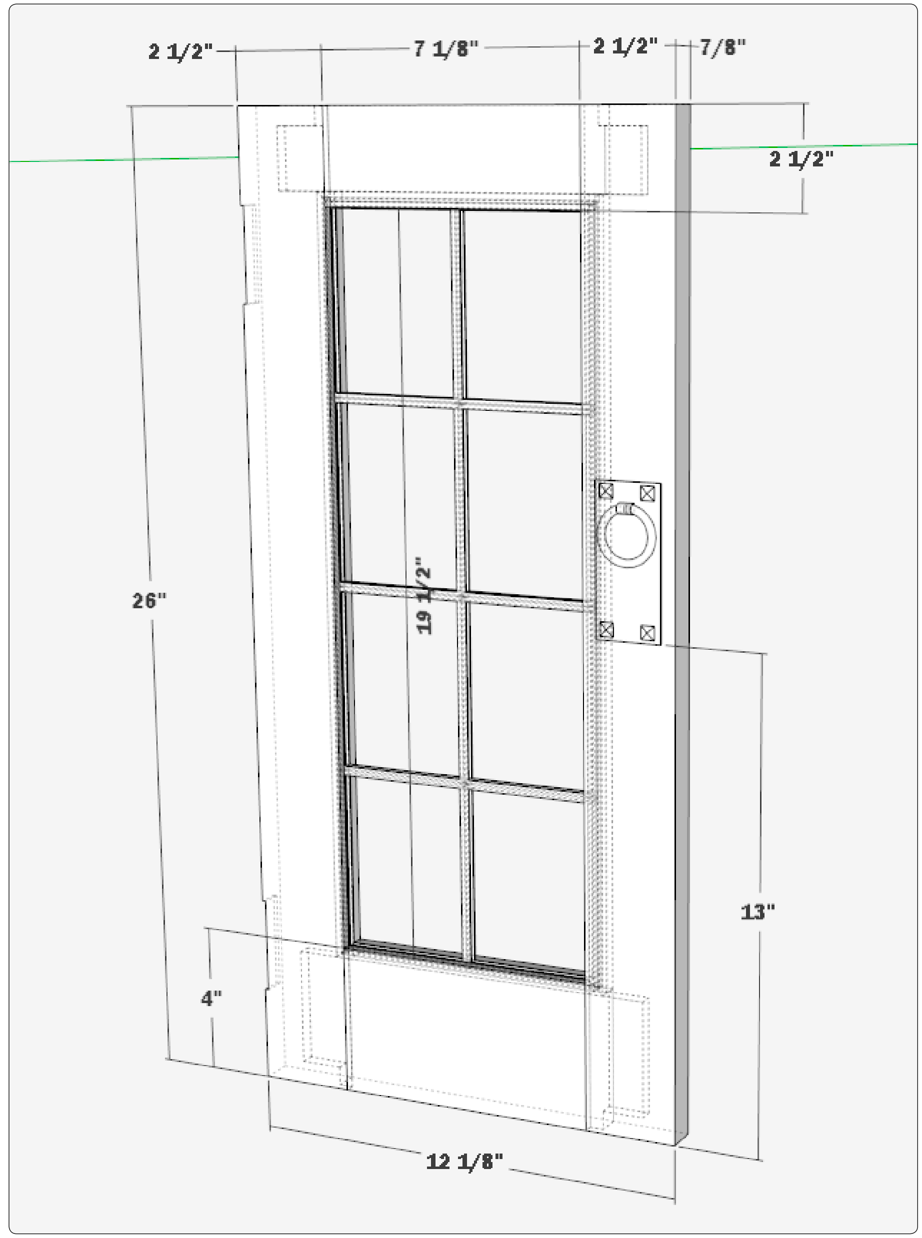


Figure 48. *Measurements for the assembled door frame and the position of the pull.*

inset ¼ in. from the front. This will make it easier to create the doors in place. The doors will inset another 1⁄16 in. from the front edge of the strips.

Step 21 First, create a reference rectangle representing the overall height and width of the door. You could skip this step and start modeling the rails and stiles. After all, Figures 54 and 59 give the dimensions for those components. However, beginning with the reference rectangle is a very direct way to create accurately sized components in position, without having to spend time measuring and checking dimensions. In addition, the components are created with the correct axis orientation, which helps when you perform flip along commands.

Draw a rectangle inside the carcase, tracing over the door opening from the hinge strip to the vertical divider. Make the rectangle a component, copy it, and pull the copy away from the carcase. Draw guidelines for the width of the stiles and rails, and trace over these guidelines with the Line Tool. See Figure 51. Now you can delete the face in the middle of the rectangle.

Draw a selection box from left to right around the vertical rectangle representing one of the stiles. Right-click on the selection and make it a component. Do the same for the upper and lower rails.

Open the Component dialog box. Click on the door stile component and move it near the door assembly. Check it closely to remove any unnecessary lines. With the Push/Pull Tool, give it a thickness of ⅞ in.

Step 22 The joinery on the stile consists of a full-length rabbet on the back inside edge

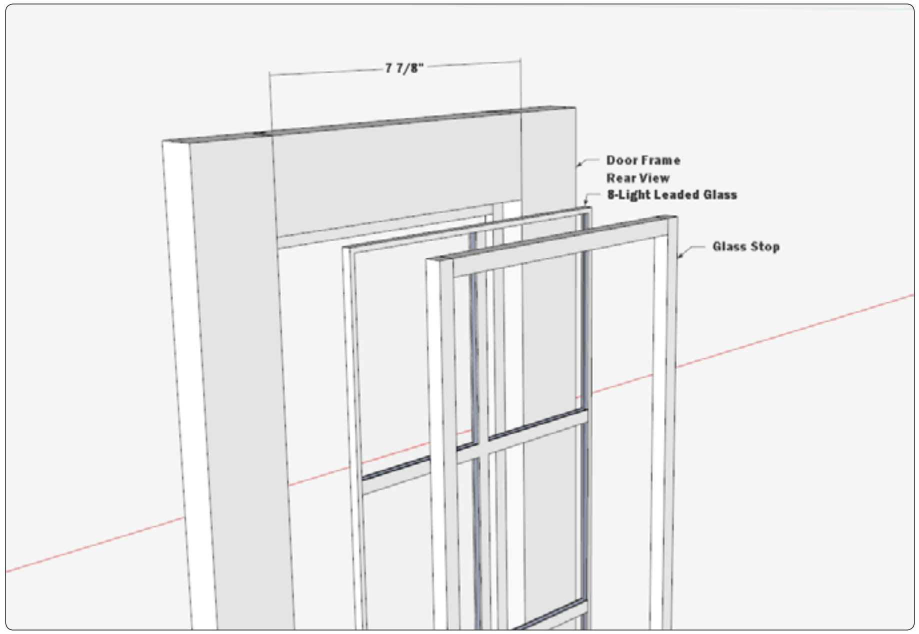


Figure 49. *A rear view of the door assembly showing the leaded glass assembly and the glass stop pulled away from the rabbet.*

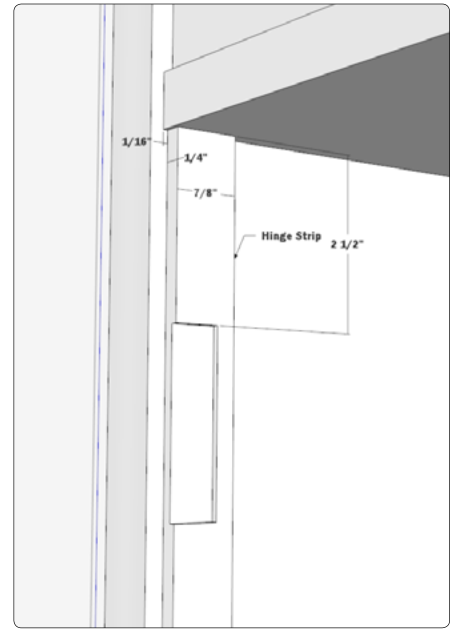


Figure 50. *Hinge strips added to the carcase make it possible to hang the doors.*

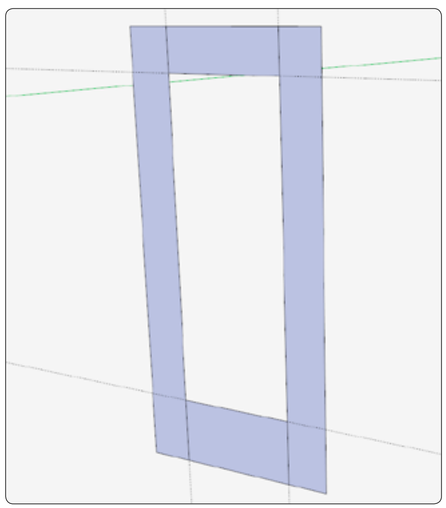


Figure 51. *Trace the sizes of the rails and stiles on the reference rectangle.*

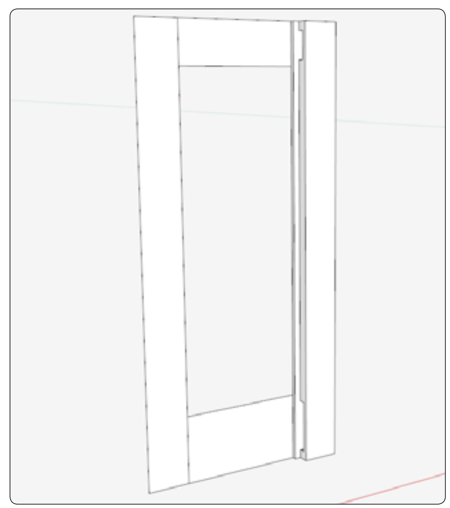


Figure 52. *A rear view of the door assembly after creating the door stile.*

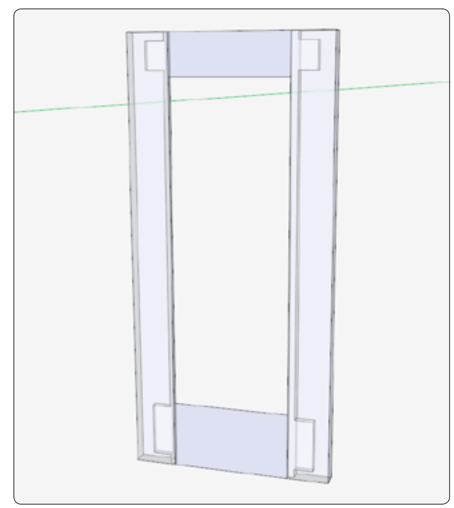


Figure 53. *An X-Ray view from the front after copying and flipping the door stile.*

and a mortise at each end. For the rabbet, draw a rectangle ⅜ in. wide by ⅝ in. deep on the back inside corner on the end of the stile. See Figure 55. Create the rabbet with the Push/Pull Tool.

The mortises, ⅜ in. thick, have a ½-in. shoulder from the stile ends. Using guidelines for reference, draw rectangles on the back of the rabbet corresponding to the size of the mortises. See Figures 55 and 56. The top mortise is 1⅝ in. long; the bottom mortise, 3⅛ in. Use the Push/Pull Tool to make the mortises 1⅛ in. deep.

Figure 52 shows a rear view of the door assembly after completing the door stile component. Copy the stile and move it to the opposite end of the reference rectangle. Execute a flip along component's red command to orient the joinery properly. See Figure 53.

Later, when you install the hinges, you will have to explode the left-hand stile and make it a new component, so that the hinge mortises won't appear in all four stiles.

Step 23 Although Figure 59 gives the dimensions for the rails, you don't need to look at them. You'll create them in position between the stiles, without measuring.

Click on the upper rail component in the reference rectangle to open it for editing. Use the Push/Pull Tool to give it a thickness of ⅞ in. See Figure 57.

Orbit around to the back side of the door assembly. You'll see a gap between the rail and the rabbet in the back of the stile. Before closing up this gap, draw a line on the end of the rail where it intersects the stile. See Figure 58. With the Push/Pull Tool, pull out the ends of the rail to close up that gap.

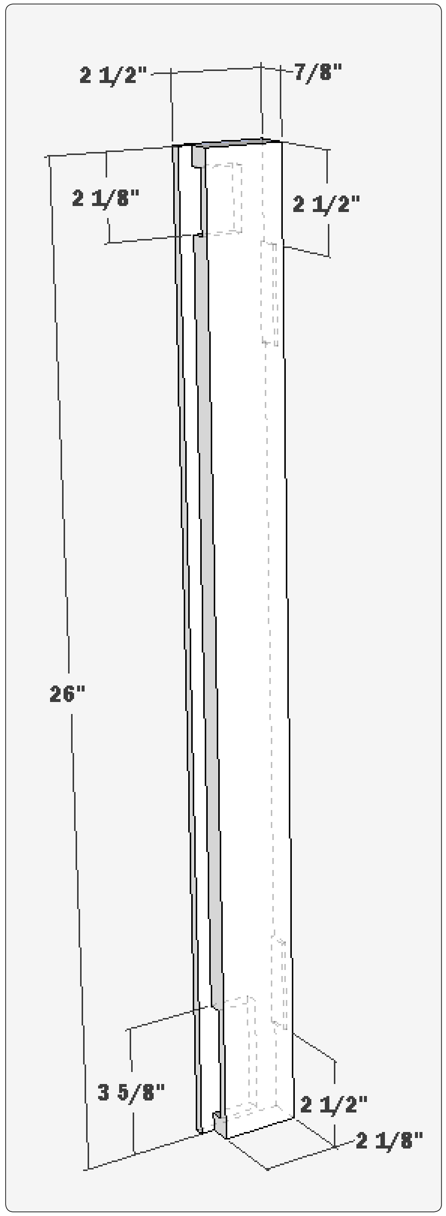


Figure 54. *The overall dimensions for the door stile.*

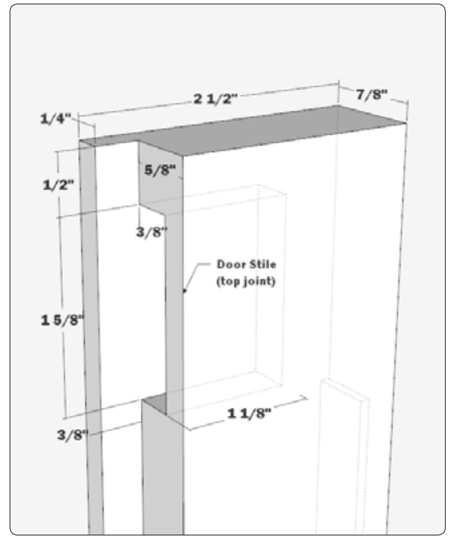


Figure 55. *Detailed dimensions for the rabbet and top mortise on the door stile.*

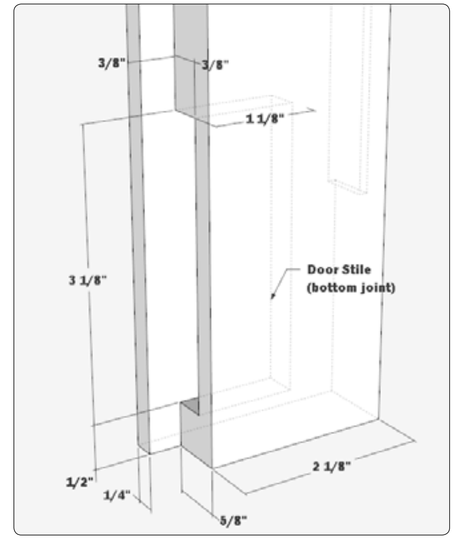


Figure 56. *Detailed dimensions for the bottom mortise on the door stile.*

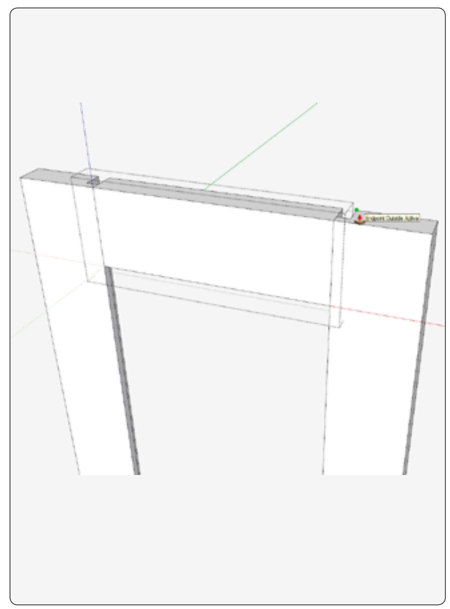


Figure 57. *Open the upper rail component and give it a thickness of ⅞ in.*

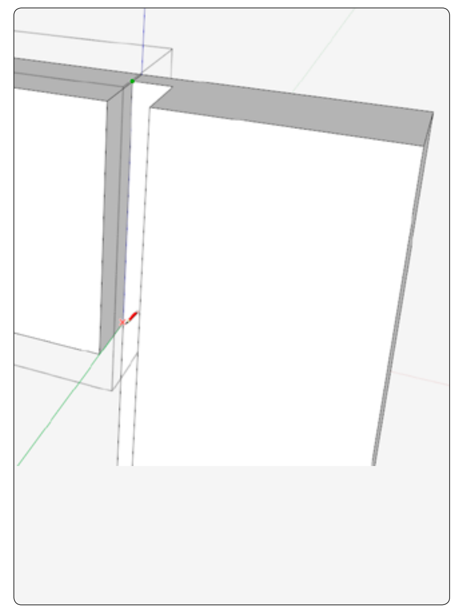


Figure 58. *Draw a line at the corner intersection with the inside edge of the stile.*

To create the rabbet on the back inside edge of the rail, place a guideline ⅜ in. up from the lower edge. Draw a line over the guideline and use the Push/Pull Tool to create the ⅝-in.-deep rabbet. See Figure 61. There will be a small, square leftover face in the corner. Delete it at both ends of the rabbet, as shown in Figure 62.

Use the mortises in the stiles to create the tenons on the rail. Turn on X-Ray and orbit for a good view of a mortise. See Figure 63. (If you have trouble seeing the mortise in the stile, review the sidebar on page 83.) Be sure the upper rail is open for editing and use the Line Tool to trace over the boundary of the mortise. Then orbit around for a view looking back to the rail through the stile. See Figure 64. Use the Push/Pull Tool to make the tenon the length of the mortise.

This completes the modeling of the upper door rail. Repeat to make the lower door rail.

Step 24 With the door structure complete, you can now create the eight-light leaded-glass assembly. It consists of glass panes held together with lead pieces and soldered together in a zinc frame.

You could rough-in the metal pieces with a few lines, but I find it quite helpful to develop all the details for features like this in SketchUp, particularly for work processes that I haven't tackled before. Working through the design in SketchUp is very educational. The time I spend making the model is paid back with new knowledge that I can apply in the actual construction.

Begin making the metal parts as you would with any other hardware, by gathering accurate information about dimensions. Pekovich told me that he bought leading

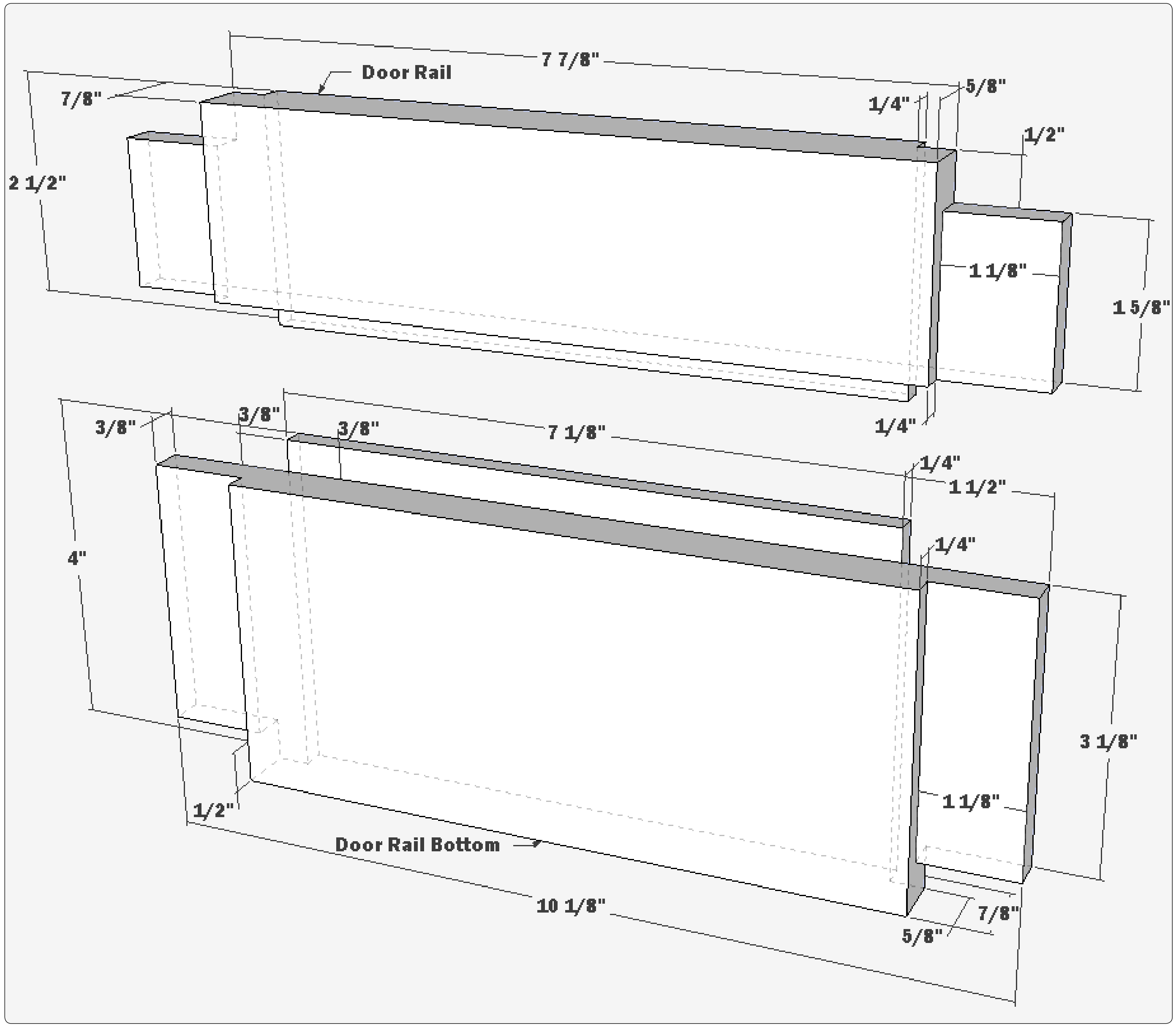


Figure 59. Detailed dimensions for the upper and lower door rails, which you can use if necessary to check your work. This view is from the rear of the rails, showing the rabbet for the leaded-glass assembly.

supplies from Cascade Lead Products Ltd. (www.delphiglass.com). Specifically, he used ¼-in. flat H wide channel lead came and ¼-in. adjustable U zinc came strip. The website provides dimensions that I used to draw cross-sections for the came and zinc strips. See Figures 65 and 66. They don't precisely match the actual shapes, but they are good enough for modeling.

Begin by modeling cross sections for whatever metal pieces you will use.

Draw a rectangle around the perimeter of the rabbet on the back of the door frame. See Figure 67. Make the rectangle a component, copy it, and move the copy away from the door frame.

Using the cross-section shape for the zinc U channel shown in Figure 66, create a frame around the perimeter of the rectangle. Place the channel shape on one corner of the rectangle, as shown in Figure 68. Explode the rectangle, select the boundary, and use the Follow Me Tool to extrude the frame. Make the frame a component.

Next, build up the lead came pieces that hold the glass within the zinc frame. This will require dividing the space into eight equal parts for the glass panes. The vertical came is centered on the top and bottom frame rails. To place the horizontal came pieces, you must first divide the vertical space into three equal parts.

Draw horizontal guidelines through the midpoint of the top and bottom frame pieces. Then draw a line on the blue axis between the two guidelines. See Figure 69. Right-click on the line and choose divide from the pop-up menu. Create four equal segments, and place a horizontal guideline at each division point.

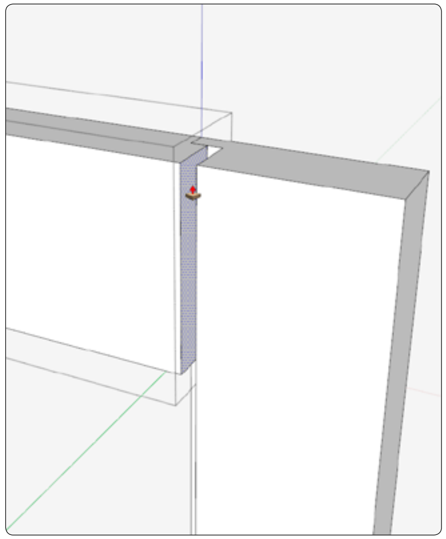


Figure 60. *Pull the ends of the rabbet to fill up the gap and rabbet of the stile.*

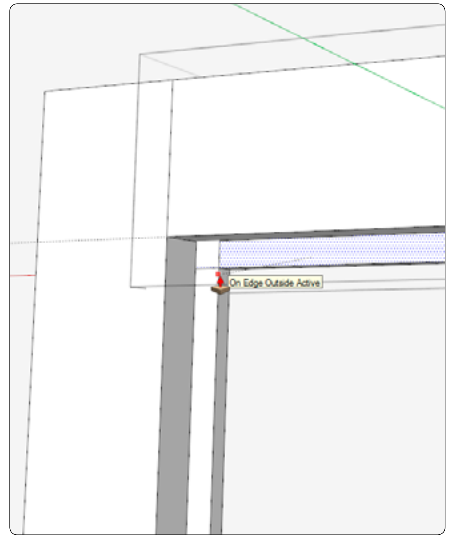


Figure 61. *Create the rabbet in the inside back edge of the rail.*

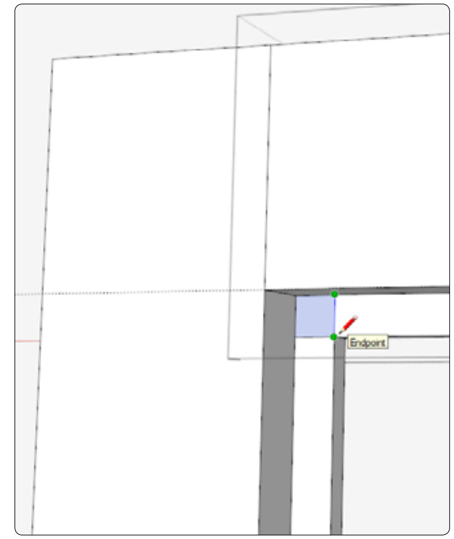


Figure 62. *Draw a vertical line before erasing a small leftover waste face.*

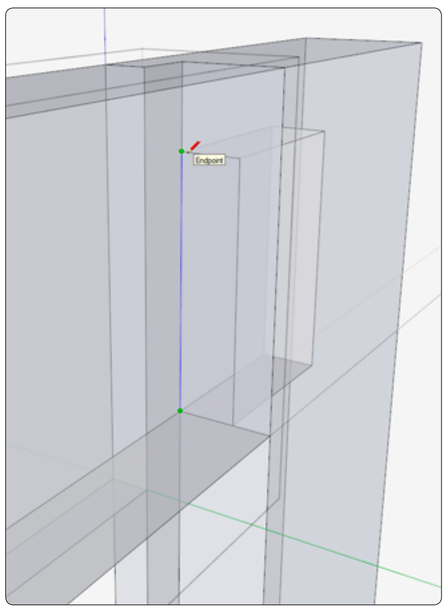


Figure 63. *Trace over the mortise boundary with the Line Tool.*

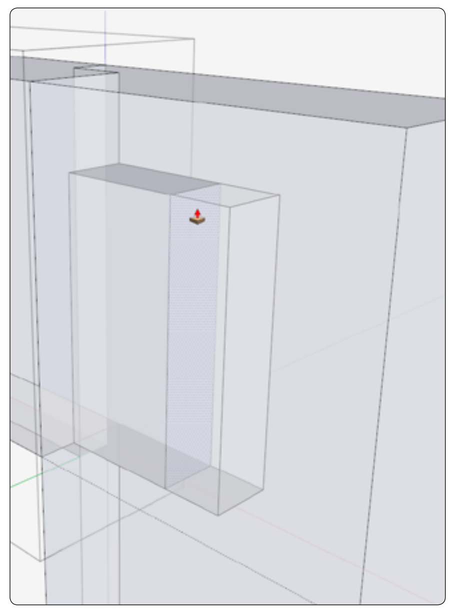


Figure 64. *Orbit to an end view and use the Push/Pull Tool to pull out the tenon.*

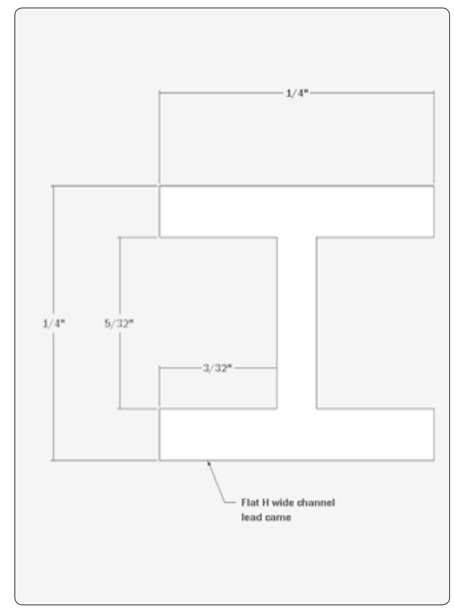


Figure 65. *Cross-sectional dimensions of the flat H wide channel lead came.*

Place a lead came shape on the inside edge and midpoint of the top rail. Use the Push/Pull Tool to pull its length down to the inside edge of the bottom rail. See Figure 70. Make this piece a component. Place another came shape on the inside edge of the zinc stile with its midpoint at the segment guideline. Pull its full length to the inside edge of the opposite stile. See Figure 71. Make this piece a component and copy it to the other two segment guideline locations.

You can make the glass inserts. These are rectangles 3¾ in. wide, 4 15/16 in. long, and ⅛ in. thick. I chose to use a standard material in SketchUp called Translucent_Glass_Gray with a very low Opacity at 15. This material and the settings are available in the Materials dialog box.

The glass frame can now be placed into the rabbet in the back of the door frame. Create the glass stop, which is a wood frame, ⅜ in. square in cross-section. You can make it as one rectangular component or as a pair of horizontal and vertical components. The stop is placed over the glass frame and fills the remaining space in the rabbet.

Step 25 The last steps in completing the door involve placing the handle, hinges, and catch. Hardware is often an afterthought in woodworking and neglected in the design work. However, the selection of hardware not only affects the style and look of the furniture, but it also impacts the design of the door and carcase parts. So I recommend choosing and buying the hardware early in the design phase. This way, these components can be built in SketchUp and incorporated into the furniture model.

I try to keep the modeling of hardware

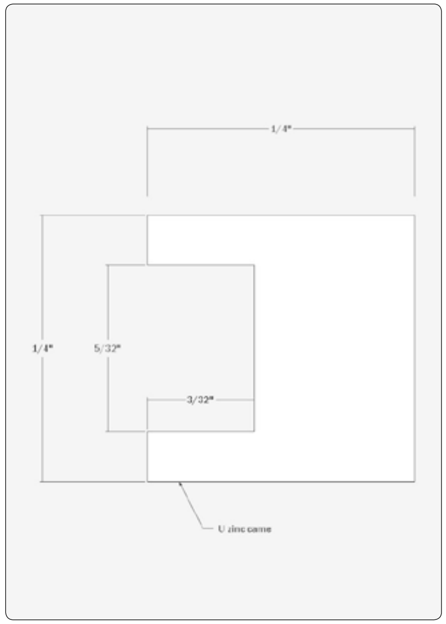


Figure 66. *Cross-sectional dimensions of the U zinc came.*

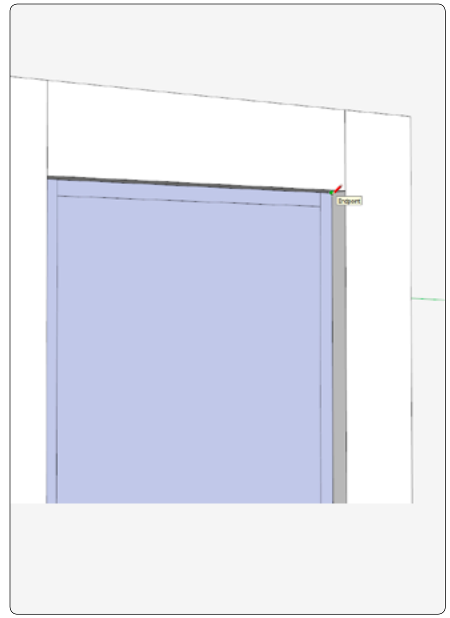


Figure 67. *Draw a rectangle within the back rabbet of the door frame.*

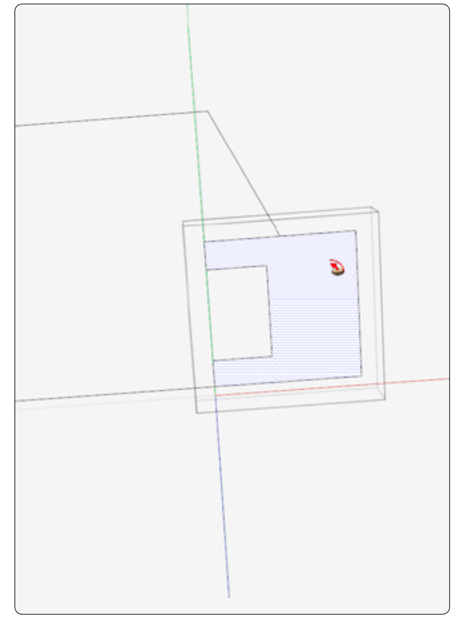


Figure 68. *Use the Follow Me Tool to create the zinc frame.*

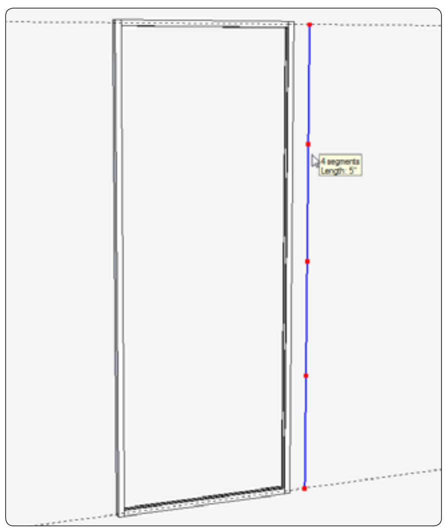


Figure 69. *Draw a line and divide it into four equal segments.*

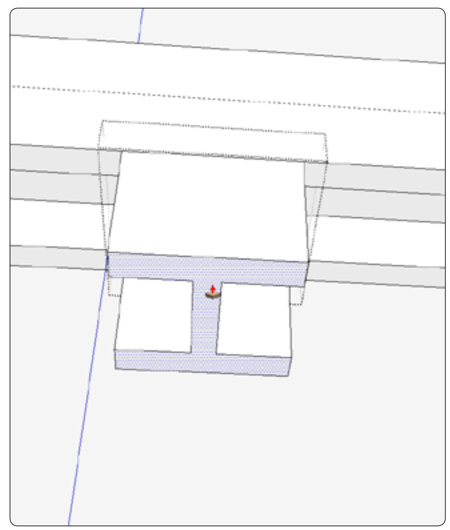


Figure 70. *Place the H came shape on the zinc frame and pull it to its full length.*

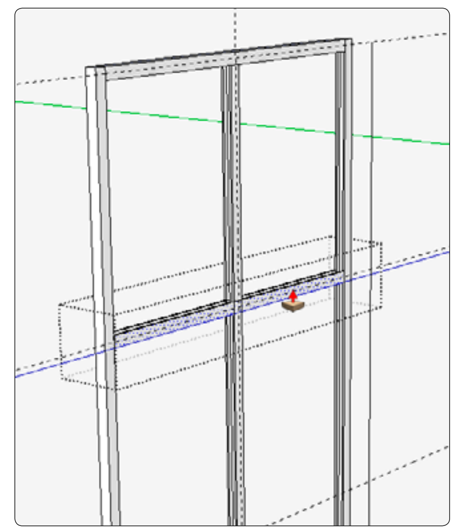


Figure 71. *Create horizontal zinc H came pieces.*

simple. I just want to show basic features and sizes that impact design. But, of course, you can create realistic models with details like the hammered surface on the pulls.

For the door pulls, begin by importing the image of the hardware from the website Arts-N-Craftshardware.com. It is the Stickley large O-drawer pull, and is 1¾ in. wide and 4 in. high. See Figure 72.

I sometimes do the hardware modeling in a separate SketchUp file so I can easily scale the size of the imported image without affecting the scale of other graphics in the file. After making the image full size, use the Line and Arc Tools to trace over the basic shapes of the ring and bolt heads, as shown in Figure 73.

For a simple, quick model, use the Push/Pull Tool to pull out the thickness of the plate, bolt, and ring, producing an element like the one shown in Figure 74. Do the same for the drawer pull, the Stickley large-O drawer pull.

The hinges are created similarly, but I tend to model them more precisely and accurately. I sometimes show the hinge in models with the door open and closed, so I like to be able to rotate the two halves around the pin center. Figure 76 shows the hinge model.

You can see an image of the specific hinges Pekovich used at www.horton-brasses.com. It is part number 409B and measures 1½ in. by 2½ in. Figure 54 shows the location of the hinge recess in the door stile. The depth of the recess is half the thickness of the hinge knuckle, or 3⁄32 in.

The last hardware item is the door stop block shown in Figure 77. It holds a rare-earth magnet that attracts a steel screw in the stile.

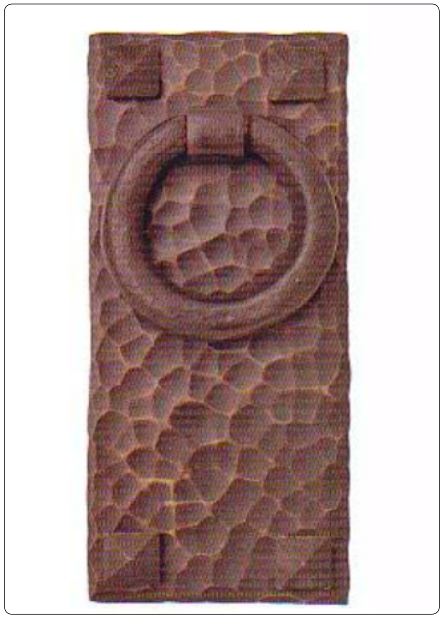


Figure 72. *Import the scanned picture from the hardware website (as an image).*

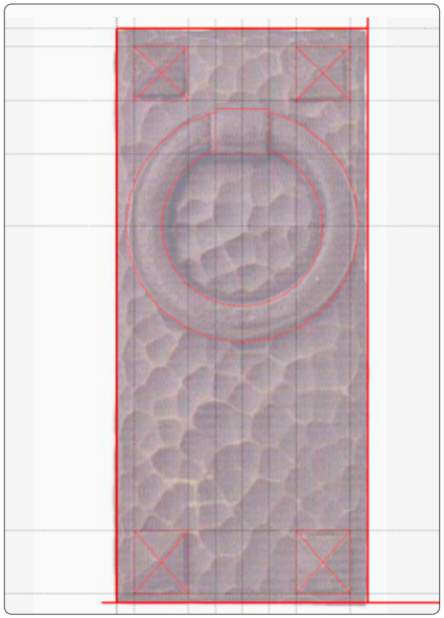


Figure 73. *Trace over the shapes with the Line and Circle Tools.*

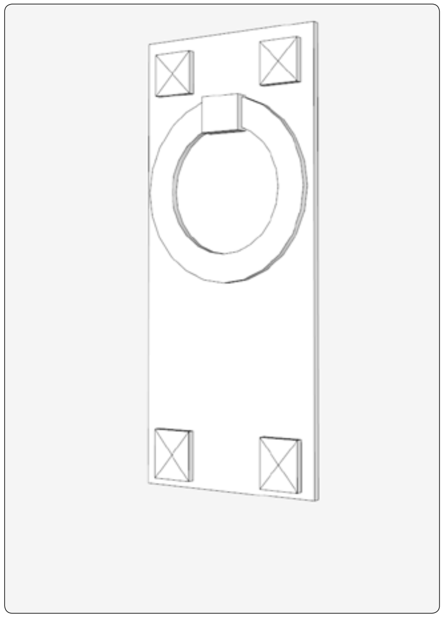


Figure 74. *Crude and simple shaping with the Push/Pull Tool.*

Figure 75. *A realistic model of the door pull. The hammered finish is a texture.*

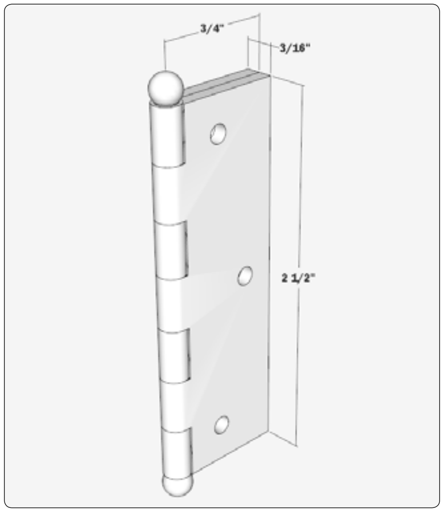


Figure 76. *The model of the hinge. It is 1½ in. wide when opened.*

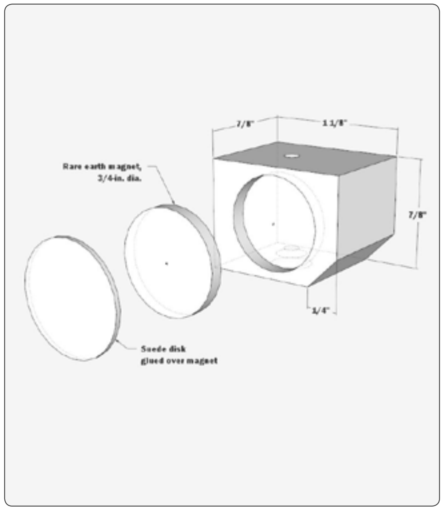


Figure 77. *The door stop is a simple, shop-made magnetic catch.*

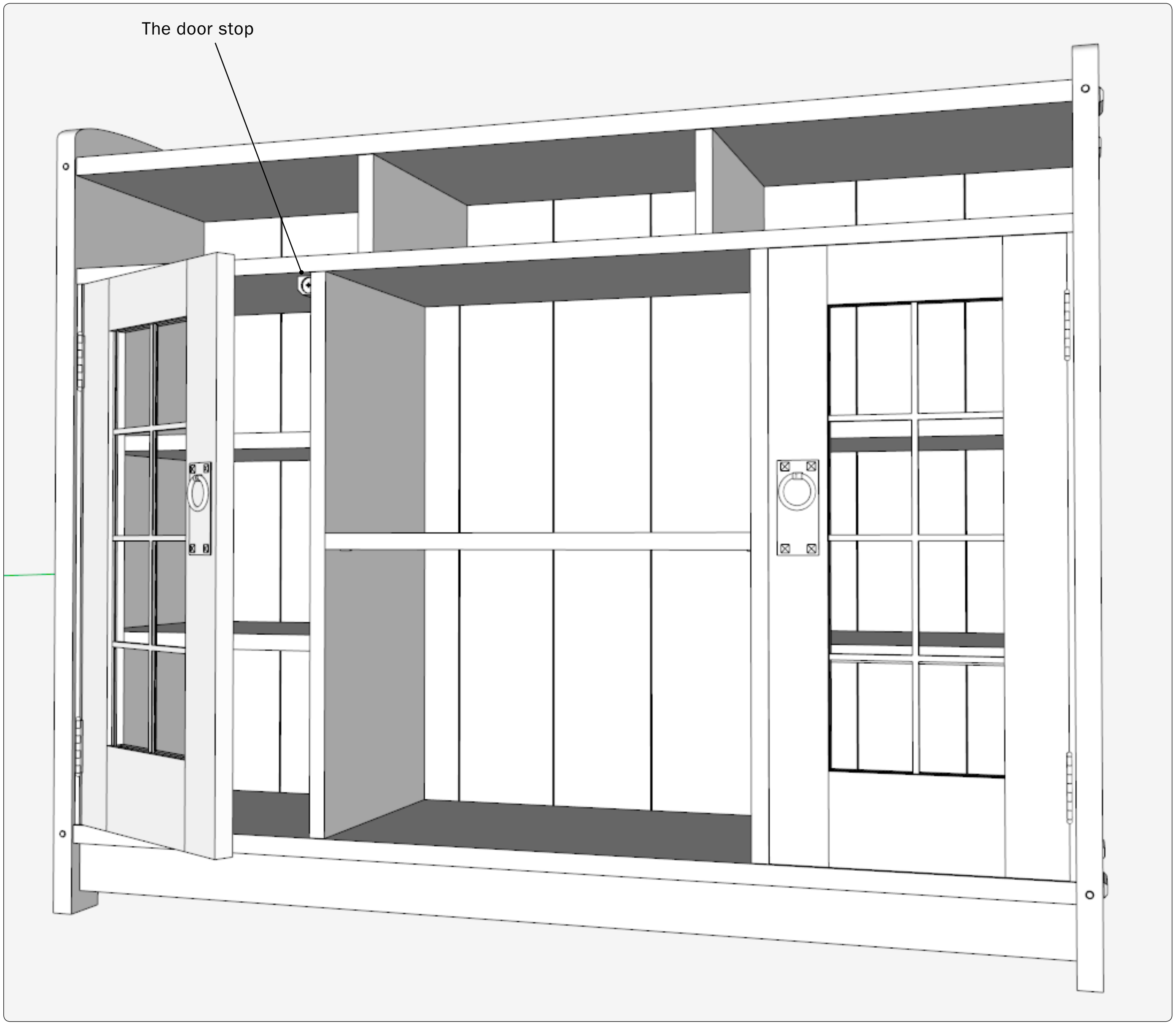


Figure 78. *The door can be rotated on the axis of the hinge pin.*

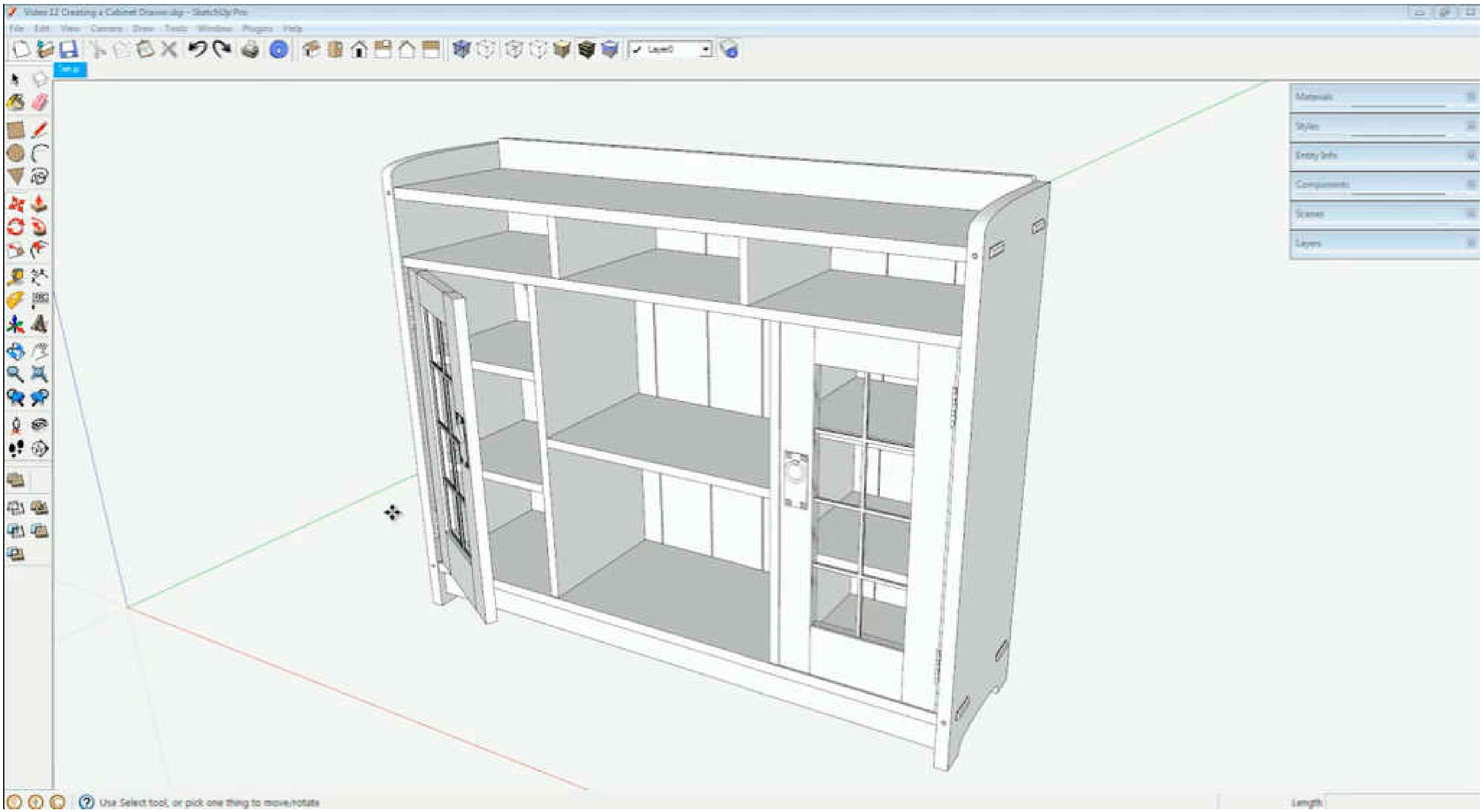
Status Report

The doors are complete and can be installed in the carcase. Just as the carcase modeling was surprisingly complex, so too were the doors. They seemed straightforward at first, but the leaded glass window entailed researching some new materials. The Internet proved a big help in finding basic information as well as drawings and dimensions for the leaded-glass material. The varying inset amounts for the door and the hinge strip also added to the time needed to complete this stage of the model.

The next section covers construction of the drawers. These are the final components needed for this cabinet.

Video Tutorial: Creating the Cabinet's Drawers

This video shows how to make the major drawer components as well as the half-blind and through dovetail joints at the corners. The accompanying text explains how to copy and resize the drawer as needed, so you can quickly create the other two while ensuring that all the drawers have identical height and depth.



Creating the Cabinet's Drawers

At first glance, the three drawers in this cabinet appear to be the same size. However the center drawer is ¼ in. wider than the ones on the ends. That means only the drawer sides are identical for all three drawers. The front, back, and bottom pieces are all larger for the center drawer.

The drawers employ several traditional design elements: half-blind dovetails at the front and through dovetails at the back; a groove in the sides and front for the drawer bottom; a drawer back flush with the top face of the bottom; and dovetail pins that are skinny compared to the tails.

The front of the drawer is inset 5⁄16 in. from the case front, and the back butts up against the carcase back panel.

Drawer parts are often thinner than the carcase pieces. For drawers this size, you might expect a ¾-in.-thick drawer front and ½-in.-thick sides and back· Here, however, the front is ⅞ in. thick; the sides, ⅝ in.

Step 26 Begin the drawer construction with the front. Place a guideline 5⁄16 in. from the front edge of the carcase for the inset. Draw a rectangle from corner to corner in the drawer opening space, as shown in Figure 83. I find it helpful to use the arrow keys to constrain the line on an axis. In this case, the lines follow the blue and red axes, which means a tap of the up or down arrow key for blue, and a tap of the right arrow for red. Make the rectangle a component and give it a thickness of ⅞ in.

For a better view, right-click on the carcase top and choose hide from the pop-up menu. Draw the drawer side, as shown in Figure 84, and make it a component.

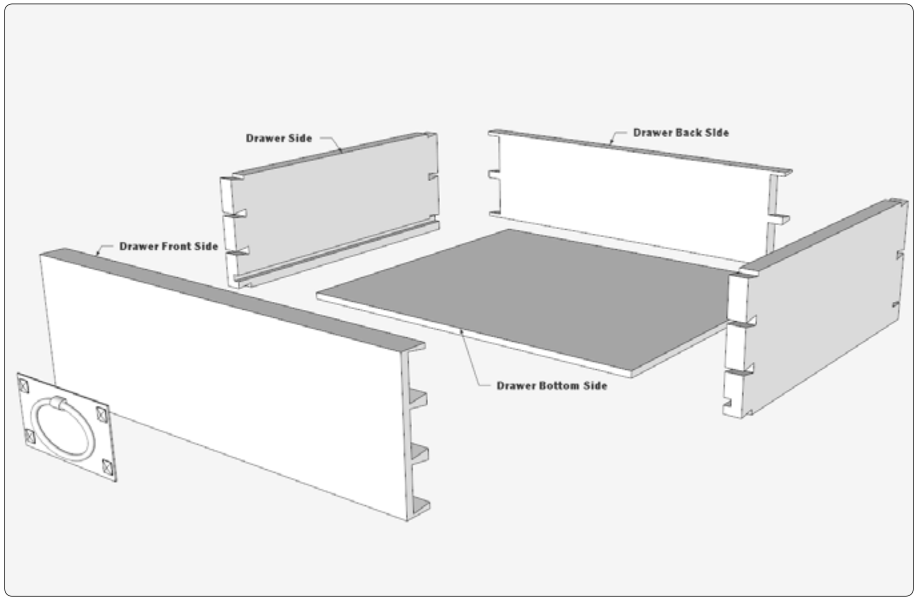


Figure 79. *An exploded view of the drawer.*

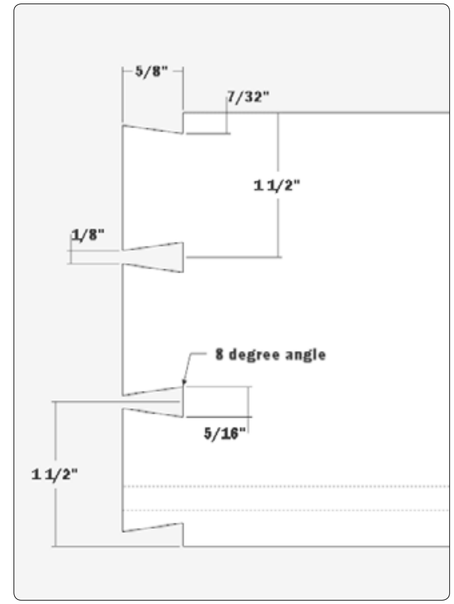


Figure 80. *The necessary dimensions for the front half-blind dovetails.*

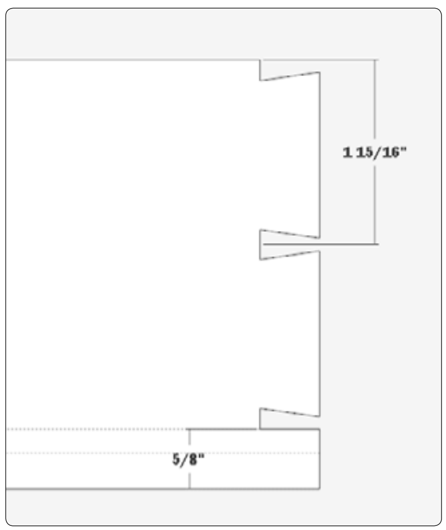


Figure 81. *The necessary dimensions for the through dovetails at the rear.*

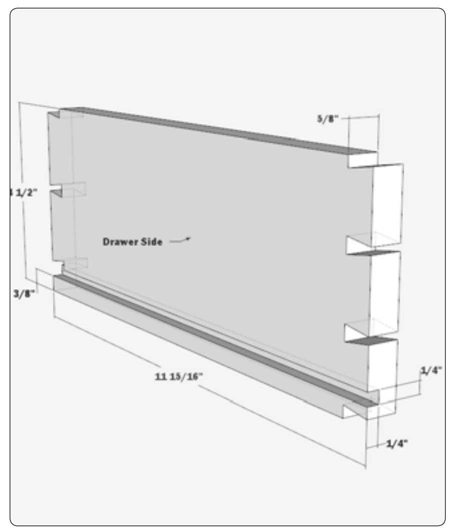


Figure 82. *The overall dimensions for the drawer side.*

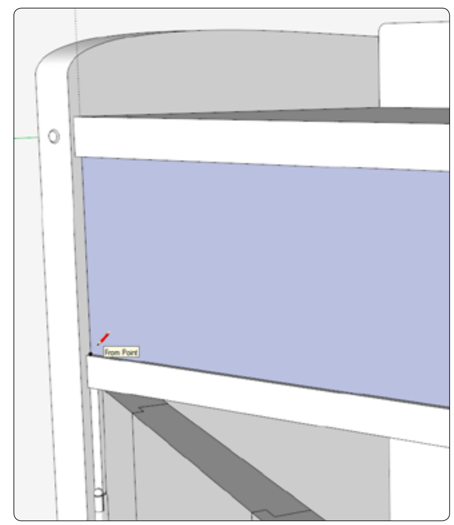


Figure 83. *Draw a rectangle within the drawer opening to begin making the front.*

Copy the front and side components and move them away from the carcase assembly. Increase the length of the side by 5/8 in. so that it overlaps the drawer front. This will make it easy to draw the half-blind dovetails. See Figure 85.

Step 27 Draw a vertical line on the face of the side, right-click on the line, and choose divide from the pop-up menu. Divide the line into four equal segments, as shown in Figure 86. The endpoints of these segments define the centerlines of the dovetails.

Place guidelines at each of the endpoints on the divided line. Then place guidelines 1/16 in. from the top and bottom edge of the side. These last two guidelines will enlarge the half dovetails slightly. This will help prevent the real half dovetails from becoming too thin when you hand-plane the top and bottom edges for a perfect fit in the carcase.

Use the Tape Measure Tool to place guidelines for the dovetail shape, following the dimensions given in Figure 80. The widest part of the dovetail is 5/16 in., so guidelines can be placed 5/32 in. from the centerline of the dovetail shape. The throat of the dovetail is 1/8 in. wide, so place guidelines 1/16 in. from the centerline.

Use the Line Tool to create the angled lines for the dovetail shape, as shown in Figure 87. Then push out the shape to the back face of the side. See Figure 88. Use the Select Tool to draw a left-to-right selection box around the entire dovetail shape (it helps to use X-Ray view to be sure you select the entire shape). With the Move/Copy Tool, grab the copy of the dovetail shape at the midpoint and move it up to the guideline location at the top edge. See Figure 89. Continue to copy the

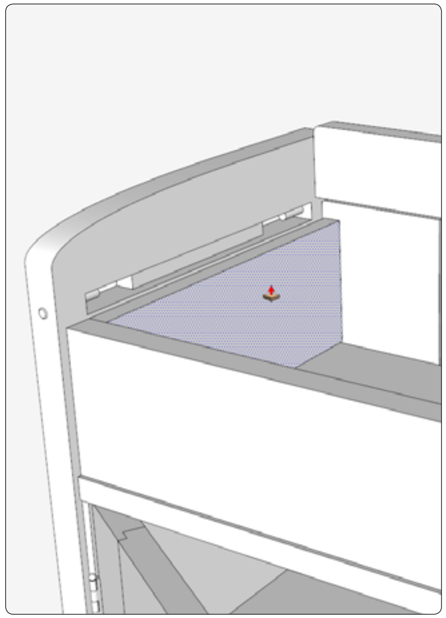


Figure 84. *Hide the carcase top and draw one drawer side in place.*

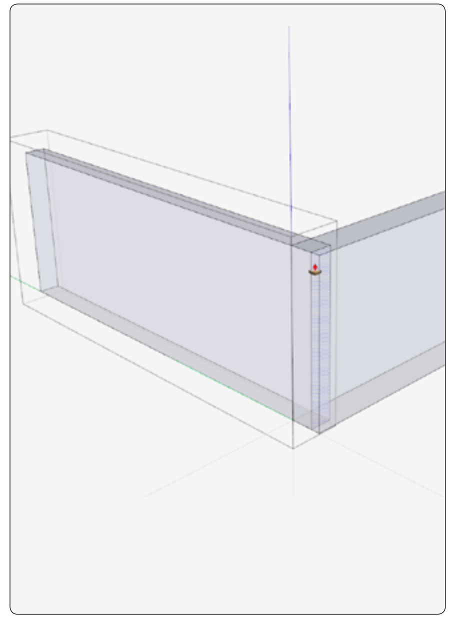


Figure 85. *Extend the front edge of the side by 5/8 in. so that it overlaps the front.*

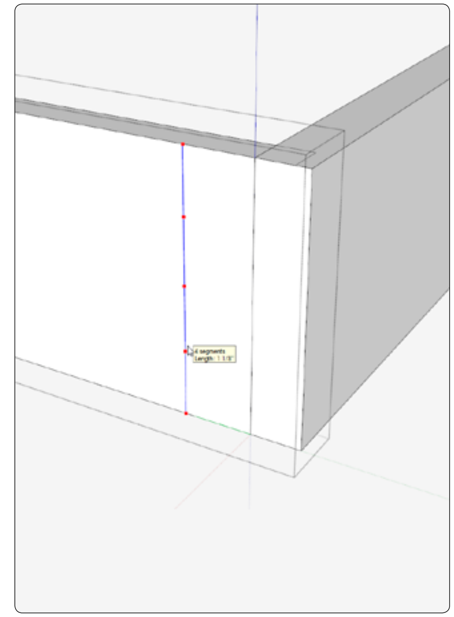


Figure 86. *Draw a line and divide it into four equal segments to position the dovetails.*

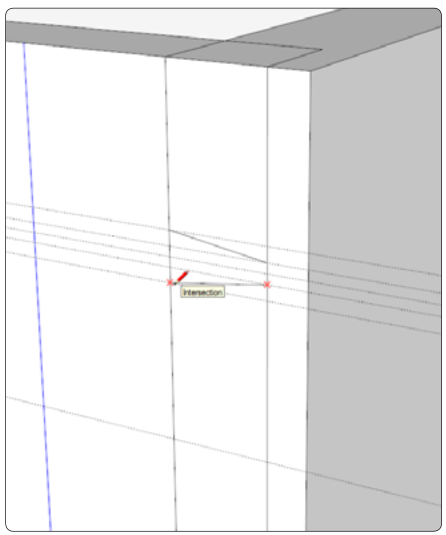


Figure 87. *Place guidelines to help draw the dovetail shape.*

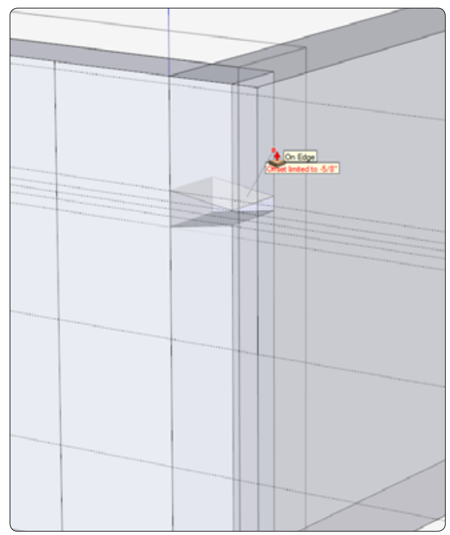


Figure 88. *Use the Push/Pull Tool to remove the waste from the dovetail shape.*

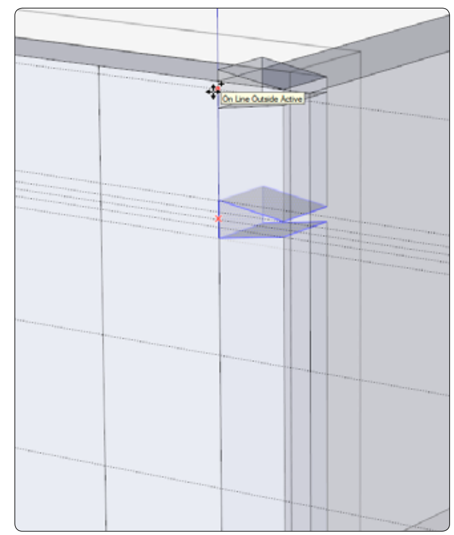


Figure 89. *Copy the dovetail shape to the other centerline locations.*

shape to the other three locations, using the segment guidelines as the centerline locations of the dovetails.

Copy the side and move it away from the front. Draw a line to "cut" the top and bottom dovetail shapes flush with the top and bottom edge of the side. See Figure 90. Use the Eraser Tool to remove the waste, then delete this copy of the side.

Open the front component for editing. Trace over the dovetail shapes on the side to make the pins on the front. See Figure 91. Use the Push/Pull Tool to remove the waste material between the pins, as shown in Figure 92.

Select the entire dovetail joint on the left end of the front and copy this joinery to the right end of the front. Execute a flip along command to orient the copy properly. See Figure 93.

Step 28 Orbit around for a rear view of the front and side. Draw guidelines to show the location of the ¼-in. x ¼-in. groove for the drawer bottom. The groove is inset ⅜ in. from the bottom edge. Draw lines over the guidelines and push out the groove in the front and side, as shown in Figure 94.

Step 29 Copy the side, execute a flip along command, and position it on the other end of the drawer front. Draw the drawer back in position, spanning the rear of the drawer sides. See Figure 95. Be sure to draw the back so that it overlaps the sides at the dovetail location.

Step 30 Create the dovetail joints in the rear corners of the drawer. Even though these are through dovetails, not half-blinds,

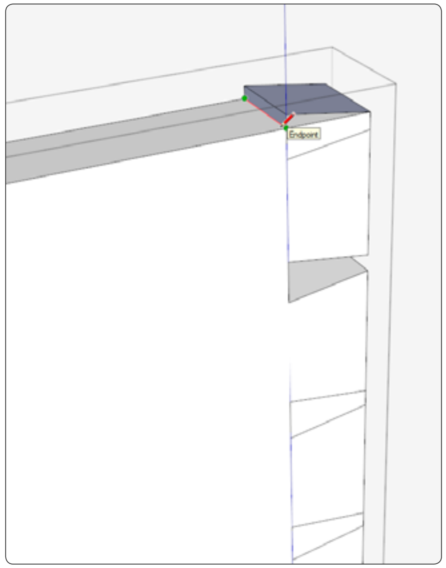


Figure 90. *Draw a line at the intersection of the dovetail and the top edge of the side.*

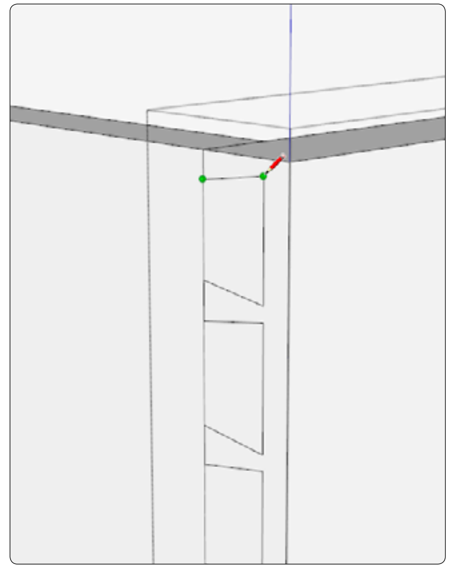


Figure 91. *Trace over the shape of the dovetails on the side on the front component.*

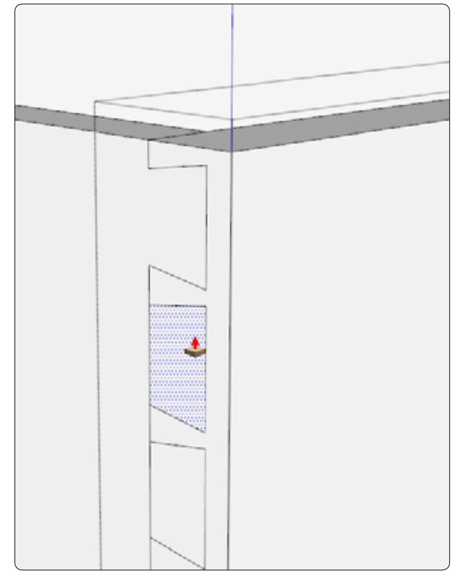


Figure 92. *Use the Push/Pull Tool to push out the waste material.*

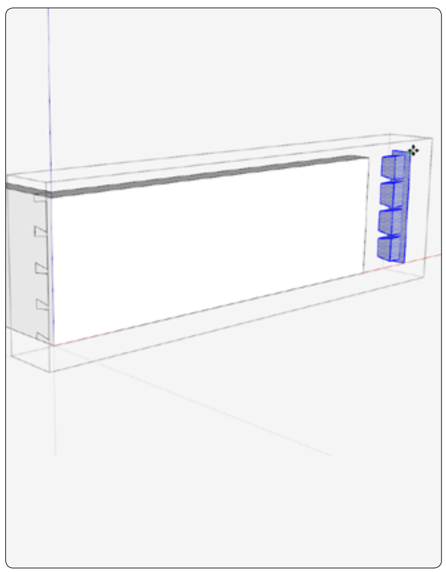


Figure 93. *Copy the dovetail joinery and move it to the other end of the drawer front.*

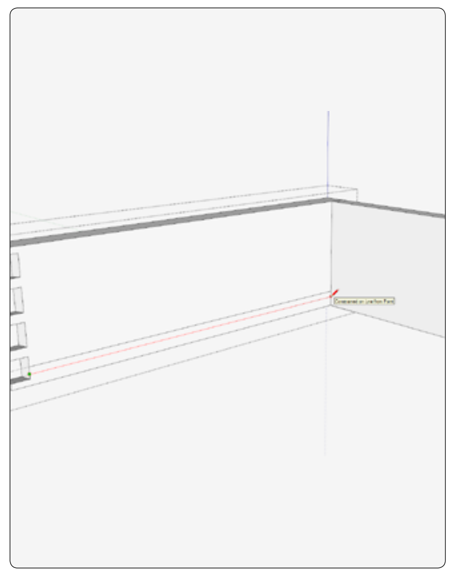


Figure 94. *Create a groove on the inside faces of the drawer front and side.*

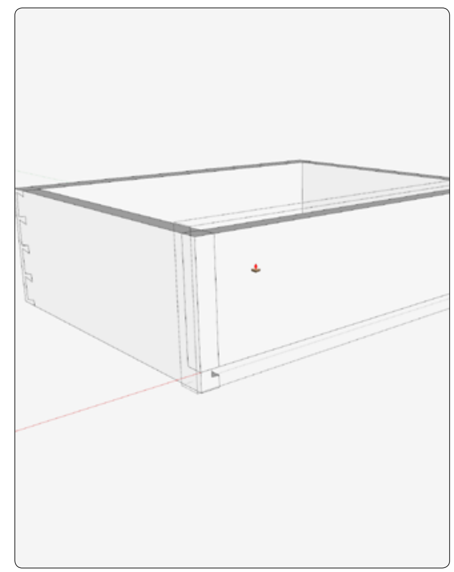


Figure 95. *Copy the side, then create the drawer back.*

the procedures are the same as you followed for the front. Draw a dovetail shape on the side, following the dimensions in Figure 81, and copy it. Then use those shapes to mark the waste between the tails on the back. Figures 96 and 97 show stages of this process.

Step 31 The drawer bottom is a solid piece of wood ⅜ in. thick. The dimensions are shown in Figure 98. In the shop, the drawer bottom is not glued but rather fastened with a screw driven through an oversized hole into the bottom edge of the back. With guidelines and the Push/Pull Tool, create the rabbet on the front and side edges. The back edge does not require a rabbet.

This completes the making of the drawers for the two ends of the cabinet.

Step 32 You can repeat the previous steps to draw the center drawer, but I think that is needlessly time-consuming and risks introducing errors to the plan. It's best to create the center drawer by using the components you made for the side drawers. The front, back, and bottom must be lengthened by ¼ in., a simple procedure.

Make a copy of the side drawer assembly. Explode the drawer front, right-click on the exploded graphics, and choose make component from the pop-up menu. Give it a new name. Do the same for the back and bottom components.

Open the center-drawer front component for editing and draw a left-to-right selection box around all the dovetail joinery at one end, as shown in Figure 99. Use the Move/Copy Tool to move the selected end of the drawer front. Constrain the move to the red axis by tapping the right arrow key. Type

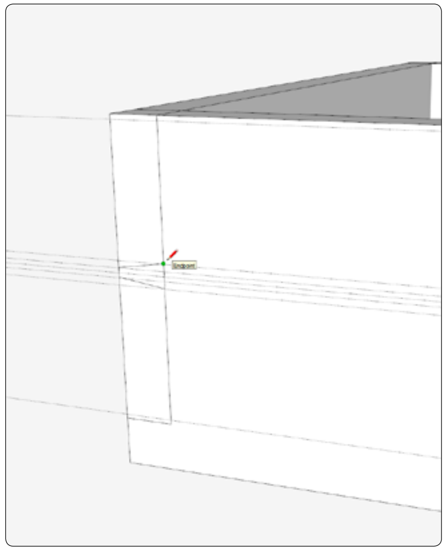


Figure 96. *Create the dovetail joints on the rear of the drawer.*

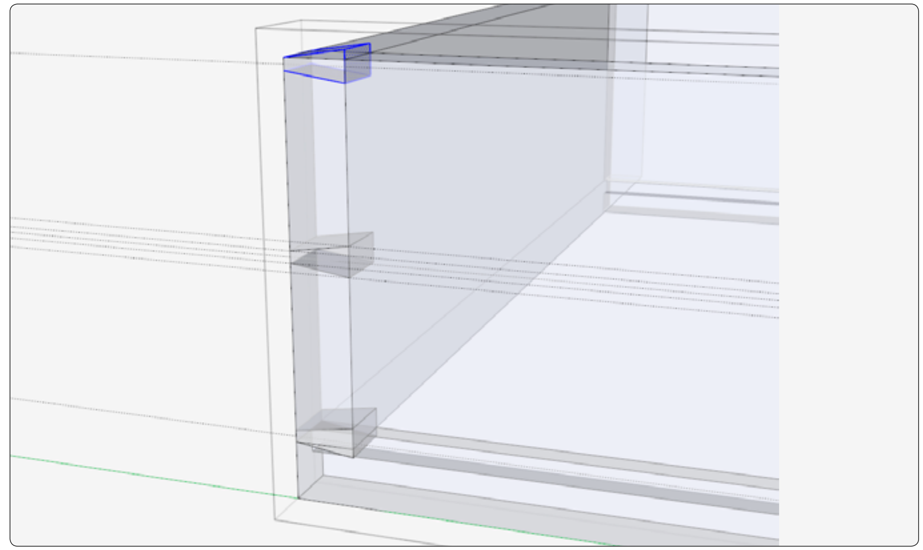


Figure 97. *As with the front dovetails, draw one shape and copy it as needed.*

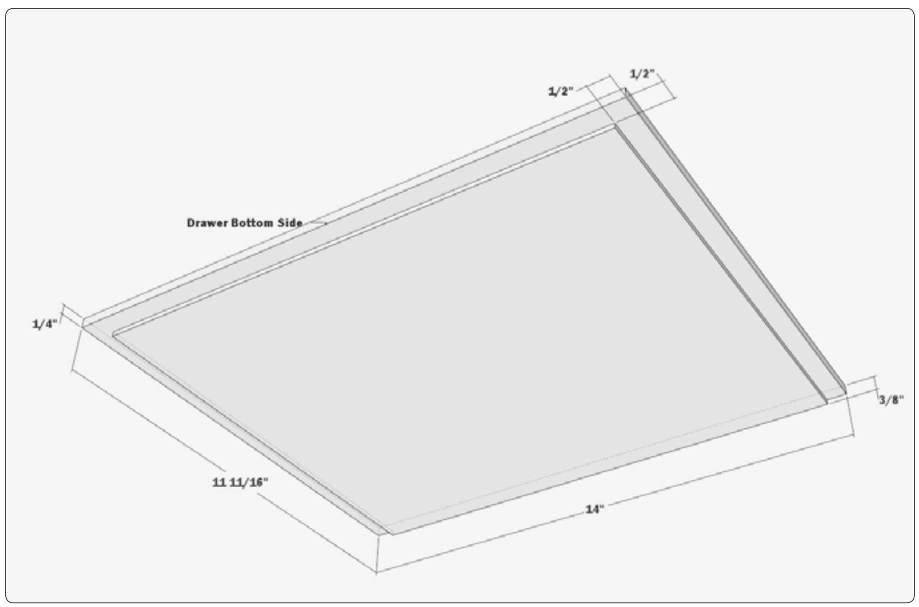


Figure 98. *The dimensions and shaping of the drawer bottom.*

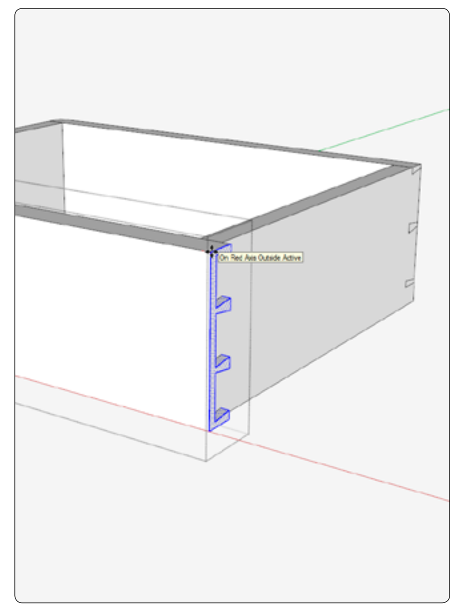


Figure 99. *Select the dovetail joinery and extend the length of the front by ¼ in.*

¼ and press enter to make the lengthening precise.

Draw a left-to-right selection box around the joinery on one end of the back, as shown in Figure 100. I've shown the actual selection box I used. It's much bigger than necessary, but ensures that I select all the important faces and edges of the dovetails. Use the Move/Copy Tool to extend the length by ¼ in. as you did the drawer front.

Move the side ¼ in., as shown in Figure 101, so the dovetails mate properly.

Then follow the same select-and-move procedure to lengthen the drawer bottom, as shown in Figure 102.

Figure 103 shows the drawer complete and assembled.

To place the drawer pull, which is centered in the face of the front, I typically use the midpoints of its edges to align the component. I use the arrow keys to constrain movement along an axis.

Another way to center an object like the drawer pull involves shifting the axis location on the pull component. Figure 104 shows the component's axes centered at the middle of the pull's back face. This is not the axes' default location, which is always on the corner.

To shift the axes, right-click on the pull and choose change axes from the menu. Place the axes at the center of the back face. When you select the pull from the Component dialog box, the Move/Copy Tool will automatically be connected to the axes' new location. This allows you to align the pull with the edge midpoints on the face of the drawer front.

This completes the modeling of the Arts and Crafts display case.

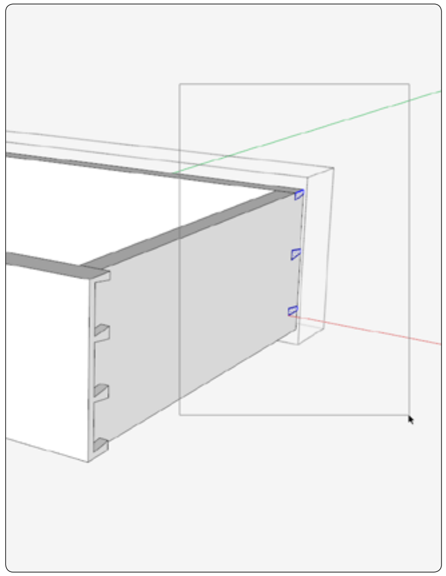


***Figure 100.** Draw a select box around the joinery in the back.*

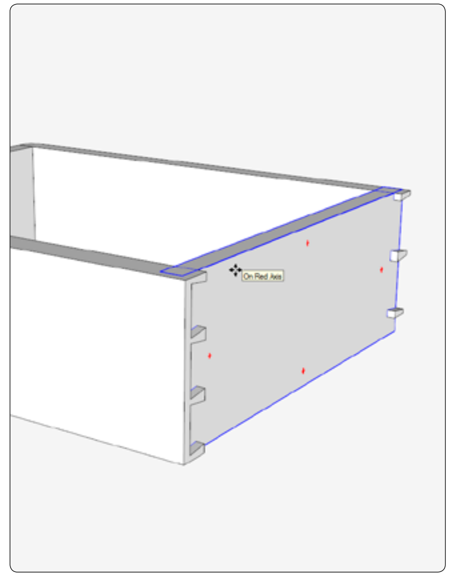


***Figure 101.** Move the side ¼ in. to fit the new lengths of the front and back.*

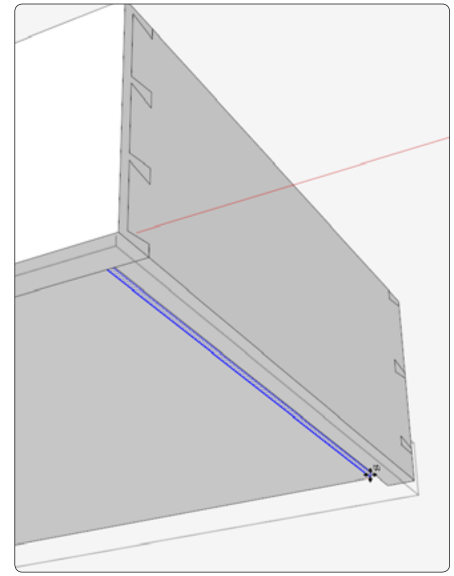


***Figure 102.** Extend the length of the bottom by ¼ in.*

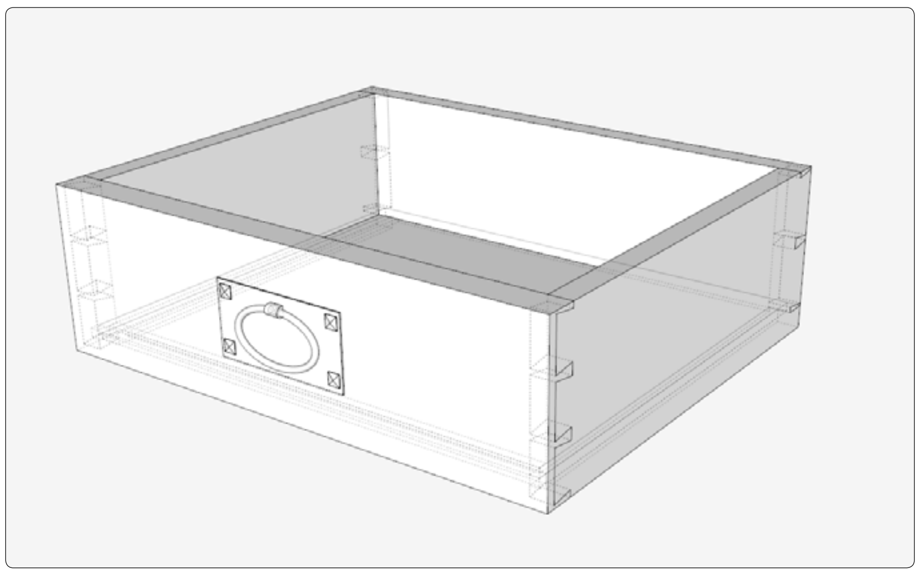


***Figure 103.** The finished and assembled drawer with the pull in place.*

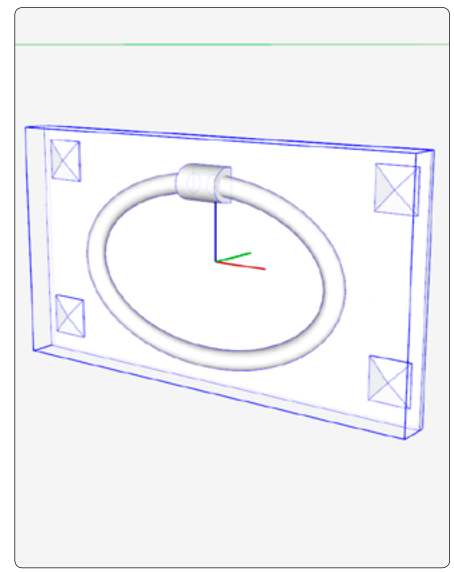


***Figure 104.** The drawer pull with axes at the center of the back face.*

American Colonial Corner Cupboard

With this project we move backward in time to the 18th century and the year 1745, when the original version of this corner cupboard was constructed in Virginia from walnut and yellow pine. It is now part of the furniture collection at New York's Metropolitan Museum of Art. The cupboard is one of many projects in *Construction of American Furniture Treasures* by Lester Margon.

Our home is filled with museum pieces based on projects in this book, which has been a principal resource for my woodworking. Margon produced several great furniture books, but this one is special because it provides ample details, dimensions, and notes that help me understand how to construct these complex pieces.

Margon's drawings are masterpieces. He was able to communicate a phenomenal amount of information in a one-page drawing, cleverly overlaying different views and detail. A prime example is his drawing for this cupboard, shown on the next page. I particularly value his perspective drawings of complicated joinery, such as the details for the cupboard doors shown below.

Seeing his drawings motivated me to improve my own drawing abilities. And his 3D-like views continually prodded me to look for ways to do something similar. But until I found SketchUp, I struggled to make anything other than flat two-dimensional representations.

This corner cupboard is big, providing lots of storage. Because it resides in a corner, it makes very efficient use of space. Its size and complexity can be intimidating at first, but it begins to make sense once you break it down into subassemblies and parts. Figure 3 shows the top-level breakdown: The cupboard consists of two stacked cabinets that are very much alike except for their height and doors.

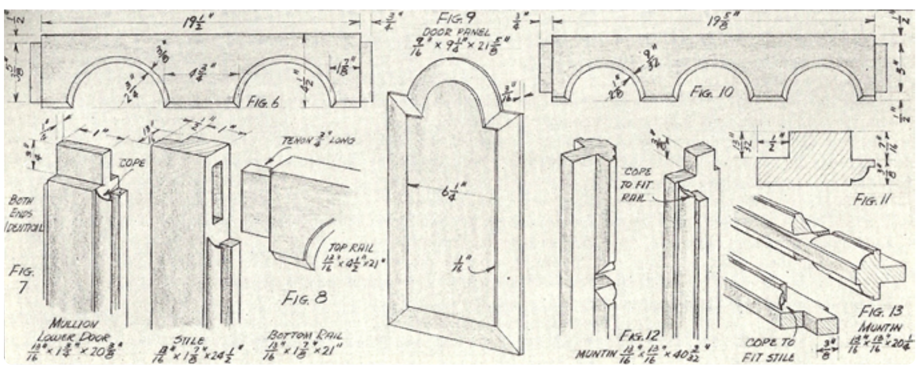


Figure 1. *Lester Margon's plans often include helpful supplementary perspective sketches of joinery and other details.*

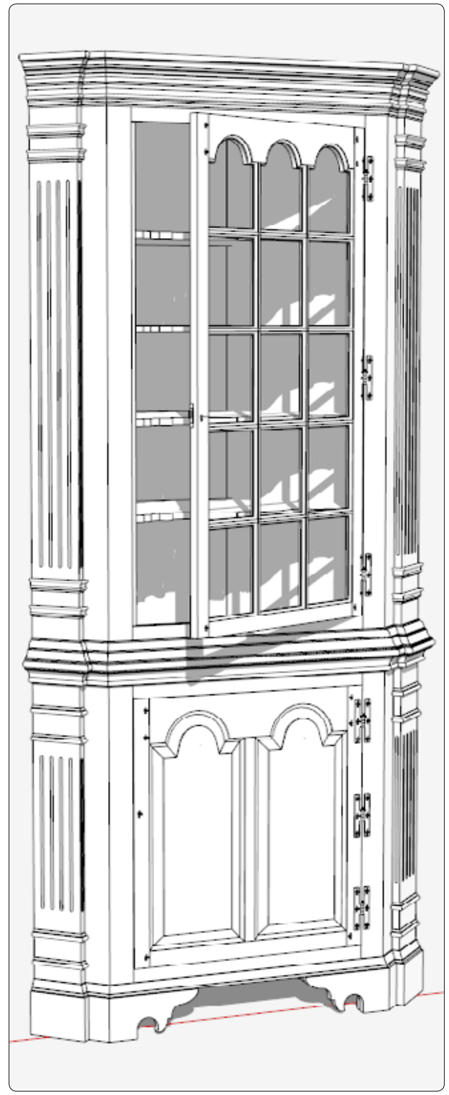


Figure 2. *The American colonial corner cupboard, built in 1745.*

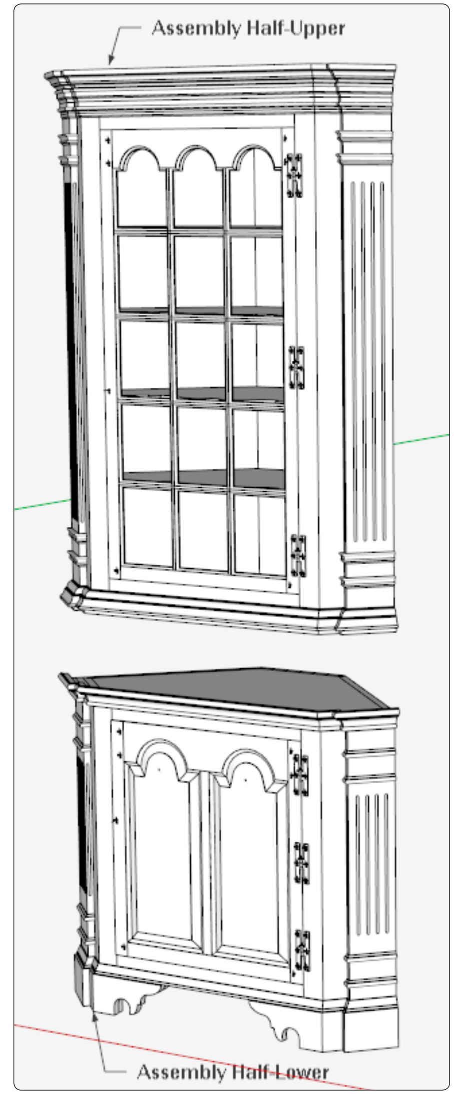


Figure 3. *The cupboard consists of two stacked assemblies.*

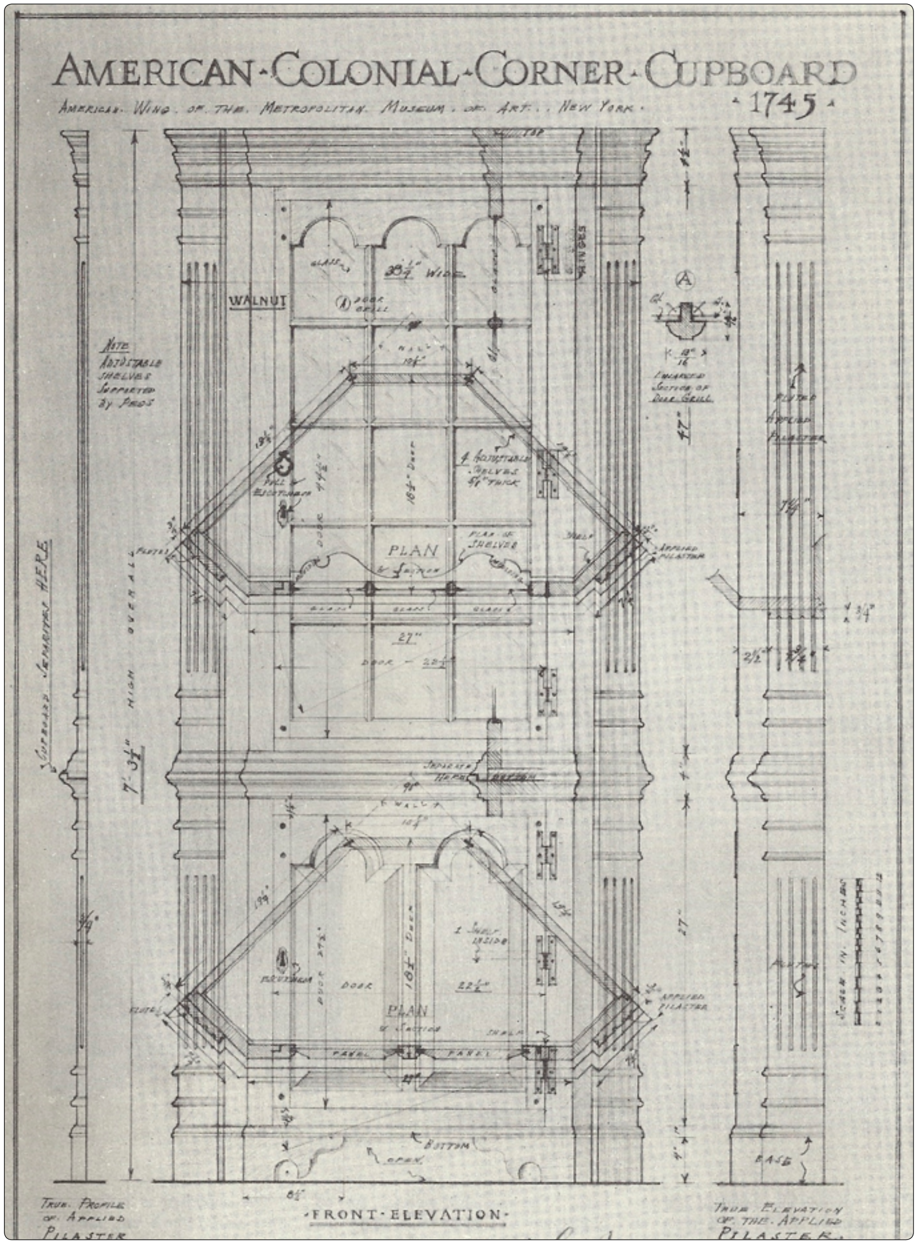


Figure 4. *Margon's principal drawing combines multiple views, plus details and dimensions.*

Lester Margon, 1892-1980

A designer of interiors and furniture, Margon studied at Cooper Union, Columbia University, and Mechanics Institute of New York. After working as a draftsman for some years with interior designers in New York, Margon began an association with the Stickley Brothers and with *Home Craftsman* magazine. He drew plans for furniture and supervised the work in the Stickley factory.

Margon spent much of his career working in museums in the United States and Europe, capturing the design of special furniture pieces. Some pieces were destroyed in World War II bombing raids, so Margon's measured drawings remain the only authentic record of their design.

In 1949 Margon published his first book, *Construction of American Furniture Treasures*. Dover Publications issued a corrected edition in 1975. He went on to produce four other books of museum drawings of furniture:

- *World Furniture Treasures*, Reinhold, 1954.
- *Masterpieces of American Furniture*, Architectural Book Publishing, 1965.
- *Masterpieces of European Furniture*, Architectural Book Publishing, 1968.
- *More American Furniture Treasures, 1620-1840: An Anthology,* Architectural Book Publishing, 1971.

In an article in *Fine Woodworking* magazine, issue No. 5, he explained his approach to working with museum pieces and how he begins his drawings:

"Making a measured drawing is not quite as simple a procedure as one might expect. Some previous experience in drafting is essential. A knowledge of the use of drafting materials is taken for granted, such as the T-square, triangles, curve, dividers, and the compass, and certainly the ability to use the scale rule.

"Generally, front and side views are required, a seat and top plan, and auxiliary views to show any special aspects of the design. Individual bits of carving can be noted separately. Put down all sizes carefully and check them before leaving. Make notes about all significant features of the design.

"This has been the beginning. When you get back to the drawing board, secure sheets of white illustration board, 20 by 30 inches, with a smooth surface. To the scale of three inches to the foot, roughly lay out the entire project."

I marvel at the beauty and effectiveness of his drafting work. His one-quarter scale makes it easy to make accurate drawings of details as small as a quarter-inch. His drawings are works of art, yet efficient in the way they communicate an abundance of technical information. I wonder what he would think about the drafting done in SketchUp.

Quantity	Description	Length(L)	Width(W)	Thickness(T)
Carcase				
2	Back	33 5/8"	19 3/32"	3/4"
1	Back Post	33 5/8"	10 1/4"	3/4"
2	Bottom/Top	35 1/32"	17 1/16"	1"
1	Left Stile	33 5/8"	2 3/4"	13/16"
1	Lower Rail	25"	2 1/4"	13/16"
1	Lower Shelf	34 11/16"	16 9/16"	5/8"
1	Right Stile	33 5/8"	2 1/4"	13/16"
4	Spline	33 5/8"	3/4"	1/4"
1	Upper Rail	25"	2 7/8"	13/16"
2	Corner Post	33 5/8"	7 1/4"	13/16"
Door				
1	Door Lock	2"	1 1/8"	
1	Door Lower Rail	21"	1 7/8"	13/16"
1	Door Mullion	20 3/8"	1 3/4"	13/16"
1	Lower Door Stile	24 1/2"	1 7/8"	13/16"
1	Lower Door Stile Left	24 1/2"	1 7/8"	13/16"
2	Door Panel	21 7/16"	9 1/8"	11/16"
3	H Hinge	4"	1 1/2"	
1	Door Upper Rail	21"	4 1/2"	13/16"
Applied Moldings				
2	Facing	8 1/2"	4"	3/4"
2	Facing 2	2 13/16"	4"	3/4"
2	Facing 3	1 1/2"	4"	3/4"
2	Facing 4	5 1/2"	4"	3/4"
2	Facing Glue Block	5 15/16"	13/16"	3/4"
1	Foot Molding		1"	1/2"
1	Lower Section Crown Molding		2 1/4"	1 3/4"
2	Pilaster	33 5/8"	4 3/4"	3/4"
8	Pilaster Molding		5/8"	3/8"

Figure 5. *The cutlist for the lower cabinet.*

Quantity	Description	Length(L)	Width(W)	Thickness(T)
Carcase				
4	Shelf	34 11/16"	16 5/16"	5/8"
1	U. Upper Rail	25"	5 3/4"	13/16"
2	Upper Back	52 7/8"	19 3/32"	3/4"
1	Upper Back Post	52 7/8"	10 1/4"	3/4"
1	Upper Bottom	37 1/4"	18 5/8"	1"
1	Upper Top	36 5/8"	18 3/16"	3/4"
1	Upper Right Stile	52 7/8"	2 1/4"	13/16"
1	Upper Left Stile	52 7/8"	2 3/4"	13/16"
2	Upper Corner Post	52 7/8"	7 1/4"	13/16"
1	Upper Lower Rail	25"	2 5/8"	13/16"
Door				
1	Upper Door Bottom Rail	21 1/8"	1 23/32"	13/16"
1	Upper Door Left Stile	44 1/2"	1 23/32"	13/16"
1	Door Lock	2"	1 1/8"	
3	H Hinge	4"	1 1/2"	
4	Horizontal Muntin	20 3/8"	13/16"	13/16"
2	Vertical Muntin	40 3/32"	13/16"	13/16"
1	Upper Door Right Stile	44 1/2"	1 23/32"	13/16"
1	Upper Door Top Rail	21 1/8"	4"	13/16"
Applied Moldings				
2	Upper Pilaster	53 7/8"	4 3/4"	3/4"
6	Pilaster Molding		5/8"	3/8"
2	Upper Pilaster Molding		1"	1/2"
1	Upper Crown Bottom		2 1/2"	1/2"
1	Upper Crown Top		2"	1 3/4"
1	Upper Base Molding		2 3/8"	1 3/8"

Figure 6. *The cutlist for the upper cabinet.*

Construct the lower carcase

In the last chapter, you started from the outside and worked your way in to construct the Arts and Crafts cabinet. It's just the opposite with this piece. You will start with the inside structure of the carcase and work your way out.

Figures 7 and 8 show the basic structure, without the pilasters, moldings, and doors. This is the assembly you would build first, whether in SketchUp or in the shop.

In my design work, I prefer not to have dimensions to the level of 32nds; 16ths are usually precise enough. I've made an exception here, showing the back dimension at 19³⁄₃₂ in., as shown in Figure 7. In order to keep the size of other components consistent with Margon's drawing—while maintaining the 90-degree angle at the back—I had to deviate from his dimensions. (He shows two widths for the back, a frequent problem with published plans.) After testing various options and making several measurements on my scanned drawing, I held the front at 27 in., the corner post at 7¼ in., and the back post at 10¼ in. I also had to modify the dimension at the back and the depth of the cabinet to make the geometry work.

Step 1 Based on dimensions shown in Figure 9, use the Line, Tape Measure, and Protractor Tools to lay out a half-shape of the carcase. Make parallel guidelines to show the thicknesses of the carcase components. Use the Line Tool to trace over the guidelines and the miter joints. Work on the red-green axes, as shown in Figure 10. Create the rabbeted joint at the corner of the back and corner post components. See Figure 11.

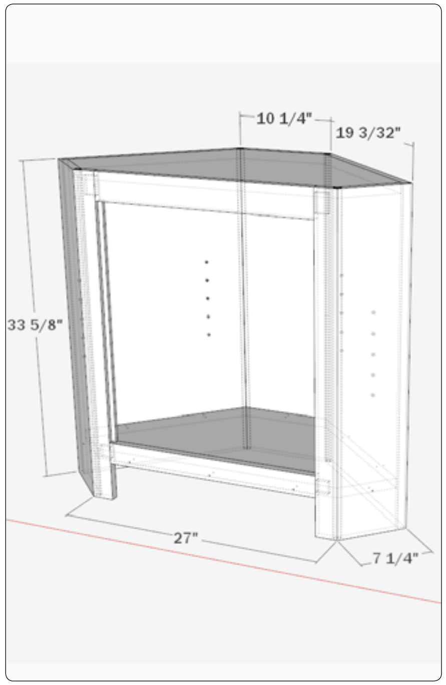


Figure 7. *The lower carcase assembly.*

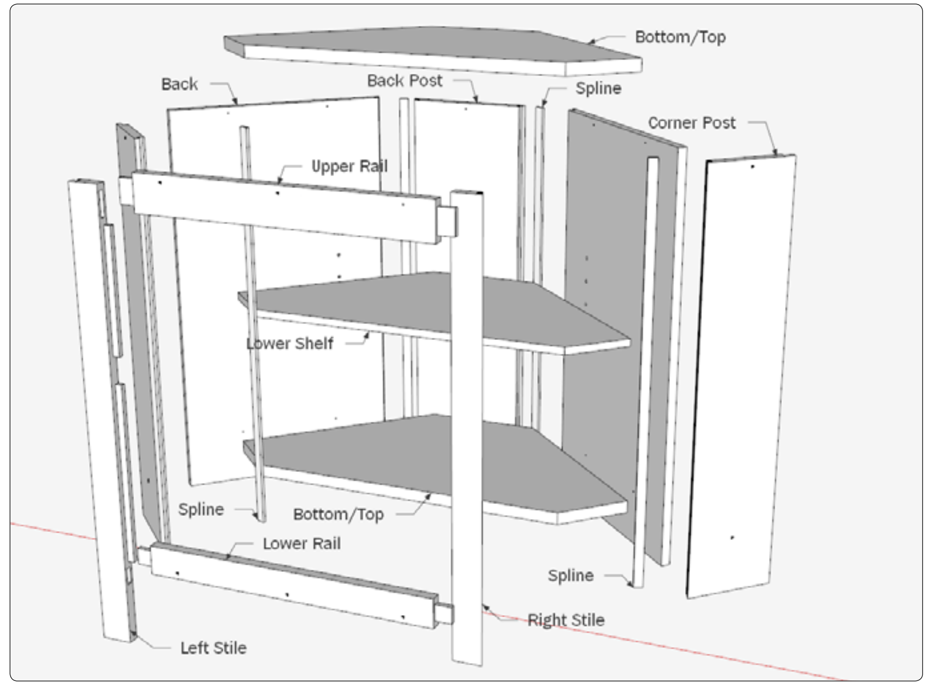


Figure 8. *An exploded view of the lower carcase.*

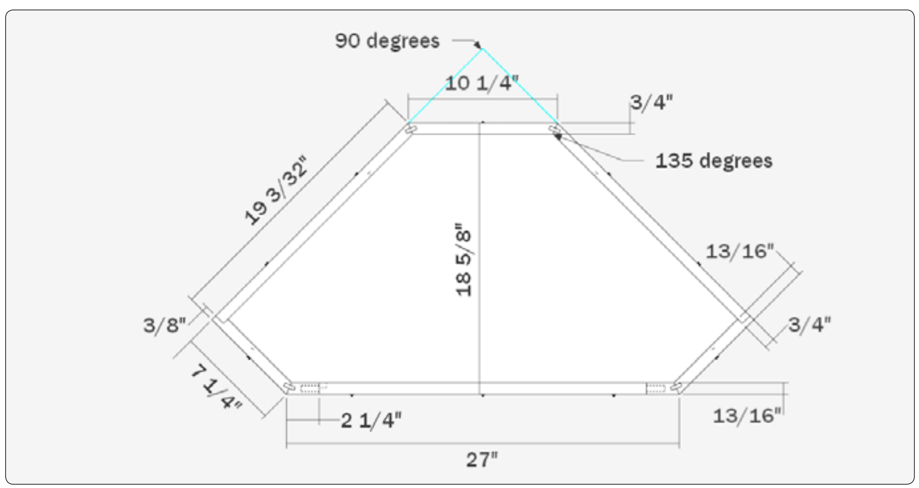


Figure 9. *A top view showing the critical dimensions for the cupboard's basic shape.*

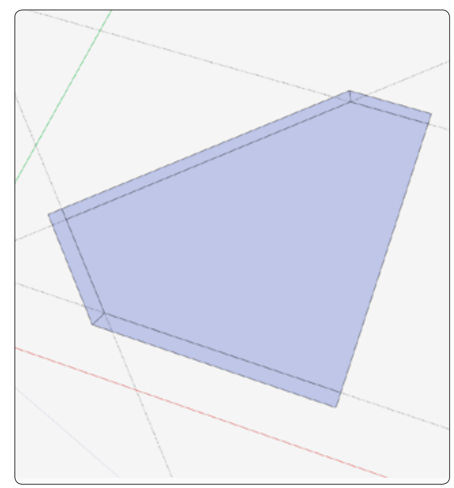


Figure 10. *Create a half-shape of the cabinet, then lay out the components.*

Step 2 Use selection boxes to make the components. Draw a left-to-right selection box around the shape of the back post, as shown in Figure 12. Make it a component. Copy the component off to the side and make the spline socket, following the dimensions shown in Figure 13. Splines connect the edges of the carcase pieces along their full height. The splines themselves are ¼ in. thick and ¾ in. wide.

Next, make the back post component its full width. Copy the component and move it to the right. Flip it along the red axis and connect it to the original. Explode both copies and select them. Right-click on the selection and make it a component again. Erase extraneous lines. Pull the back post up to its 33 ⅝-in. height. See Figure 14.

Step 3 Create the back component and make its spline socket where it meets the back post. See Figure 15.

Make the corner post and create its spline joint. Pull the corner post to its full height, as shown in Figure 16.

There is one more splined piece to make: the front stile. For its width, place a line 2¼ in. from the front edge of the center post, as shown in Figure 17. Draw a left-to-right selection box around the shape, make it a component, and pull it up to its full height. Create the spline socket in the stile where it joins the corner post.

Step 4 To make the spline, draw lines around the rectangular shape of the spline socket on the corner post and back components. See Figure 18. Double-click on the face, right-click, and make the shape a component. Make the spline 33⅝ in. long.

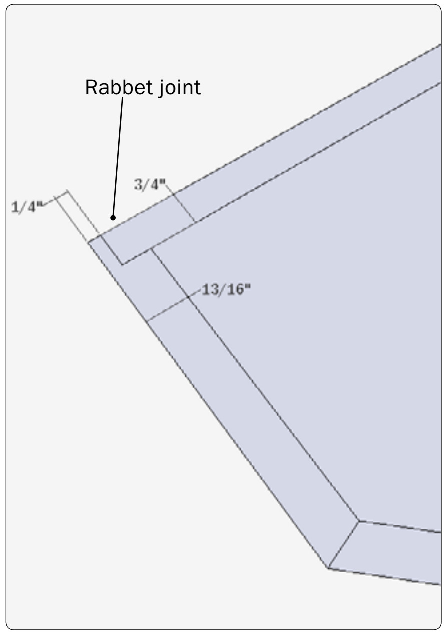


Figure 11. *Create the rabbet joint at the corner of the back and the front post.*

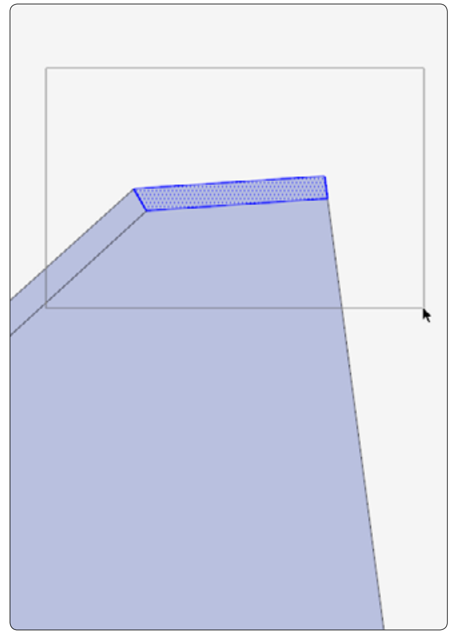


Figure 12. *Select the back post shape and make it a component.*

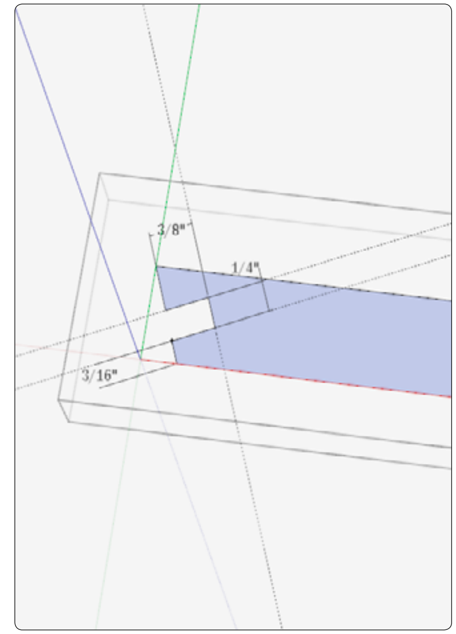


Figure 13. *Working with a copy of the back post, create the spline socket.*

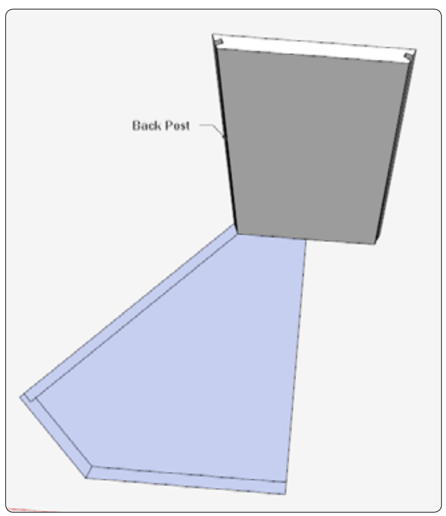


Figure 14. *Make the back post component its full width and height.*

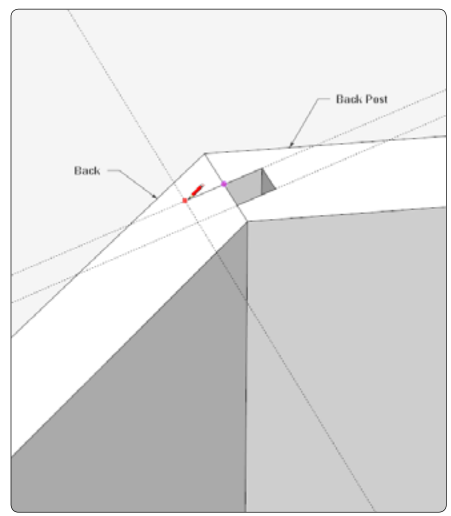


Figure 15. *Make the back. Create the spline socket to match the one in the back post.*

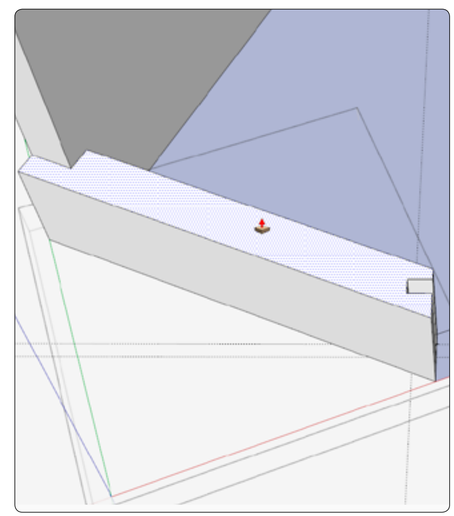


Figure 16. *Pull the corner post up to its full height.*

Copy it to the back joint location, as shown in Figure 19, and rotate it to fit. Connect one of the corners of the spline to a corresponding corner of the spline socket. Select the spline and choose the Rotate Tool. Click the tool on the corner connection, then click again on the edge of the spline to begin the rotation. Swing the spline around until the corners connect and the spline is aligned properly. Click again to stop the rotation.

Step 5 Select the splines, the back, the front post, and the front stile. Copy those components and flip them along the red direction. Join the copies where the back and back post meet. Be sure that there is 27 in. between the outside edges of the corner posts and that all the splines fit their sockets properly.

Step 6 Based on the dimensions shown in Figures 23, 24, and 25, place guidelines on the assembled carcase for the location and size of the two frame rails. Draw lines to create the faces of the rails and make them components. See Figure 20. Make the rails 13/16 in. thick. Copy one rail and move it away from the assembly.

Make a tenon 3/8 in. thick and 1 1/4 in. long on one end of the rail. Copy and flip the tenon to the other end of the rail. Repeat those steps to create the tenons on the other rail. Delete the copied components.

Switch to X-Ray style for better visibility and use the rail tenons to make the mortises in the front stiles. See Figure 21. Only the left stile has a rabbet on one edge. Before you create that, explode the left stile and make it a separate component.

To make the rabbet, begin by opening

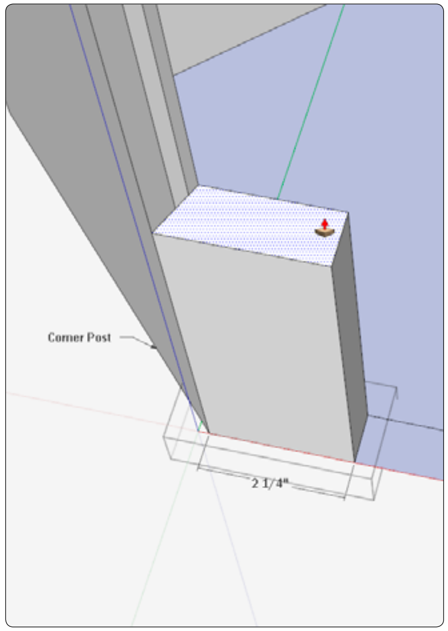


Figure 17. *Create the front stile component in the front carcase frame.*

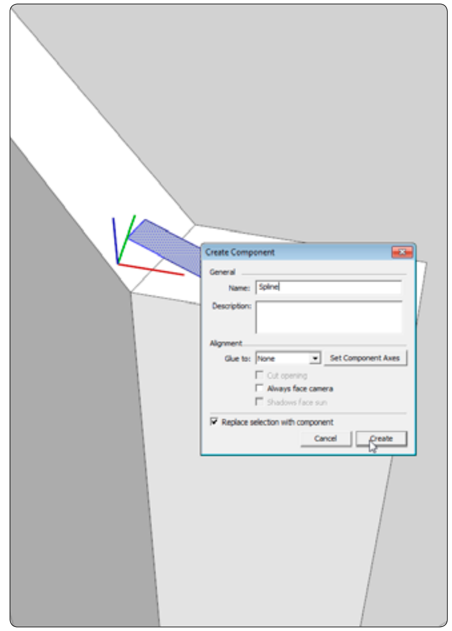


Figure 18. *Create the spline and make it the same height as the other components.*

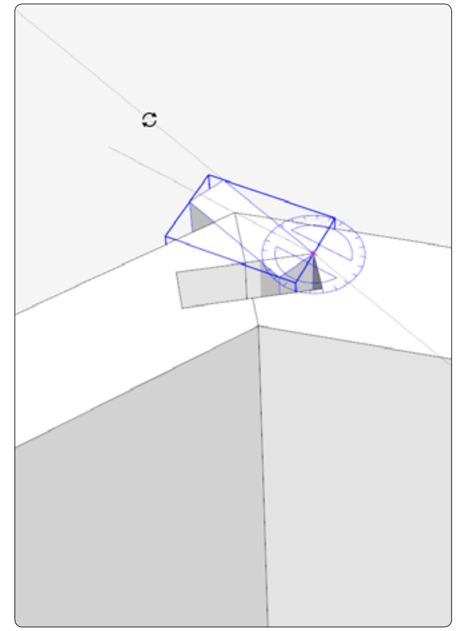


Figure 19. *Rotate a copy of the spline and position it in the joint at the rear of the case.*

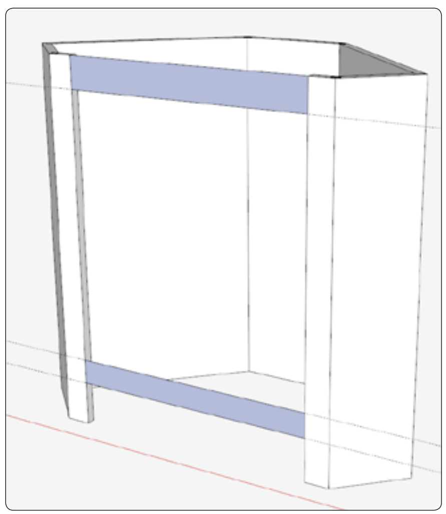


Figure 20. *Create the front frame rails in position in the carcase assembly.*

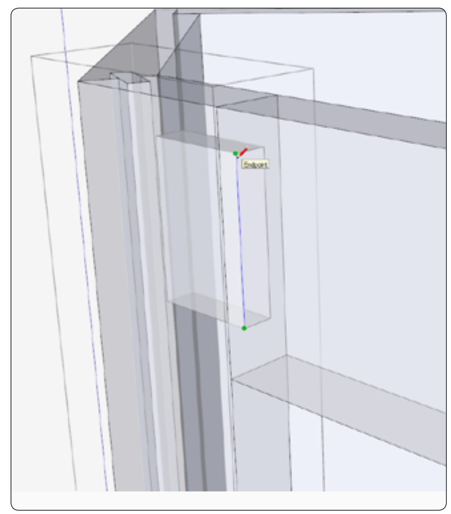


Figure 21. *Use the rail tenons to make the mortises in the front stiles.*

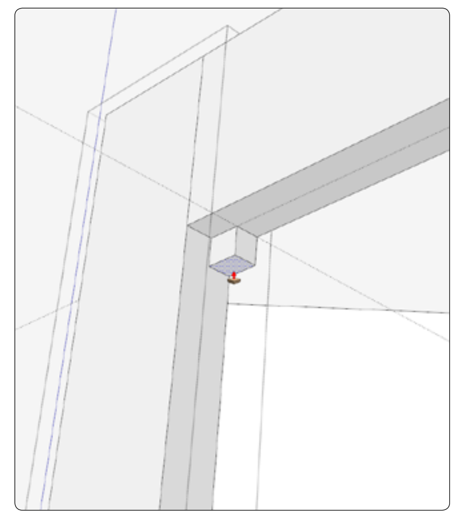


Figure 22. *Make the rabbet on the inside edge of the left stile.*

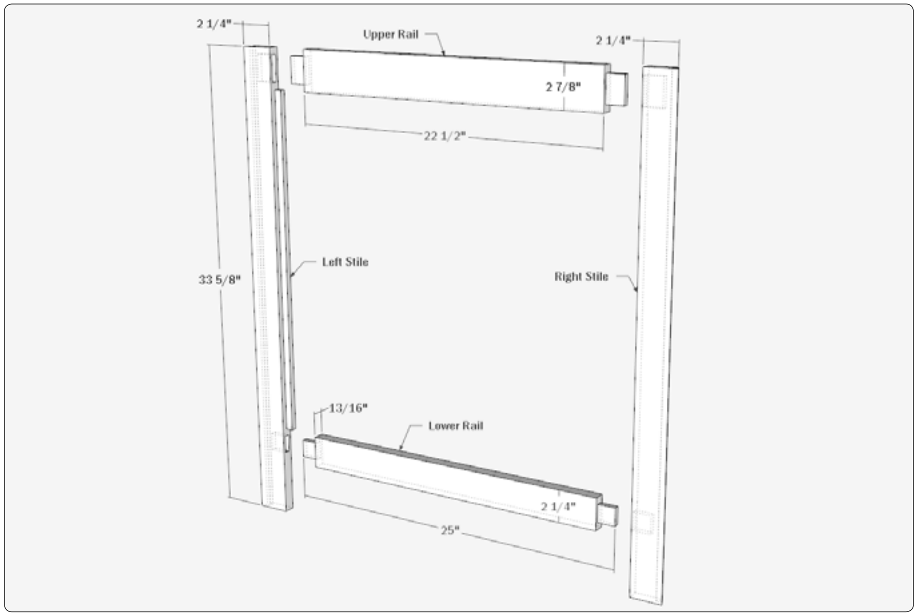


Figure 23. *An exploded view of the carcase front frame.*

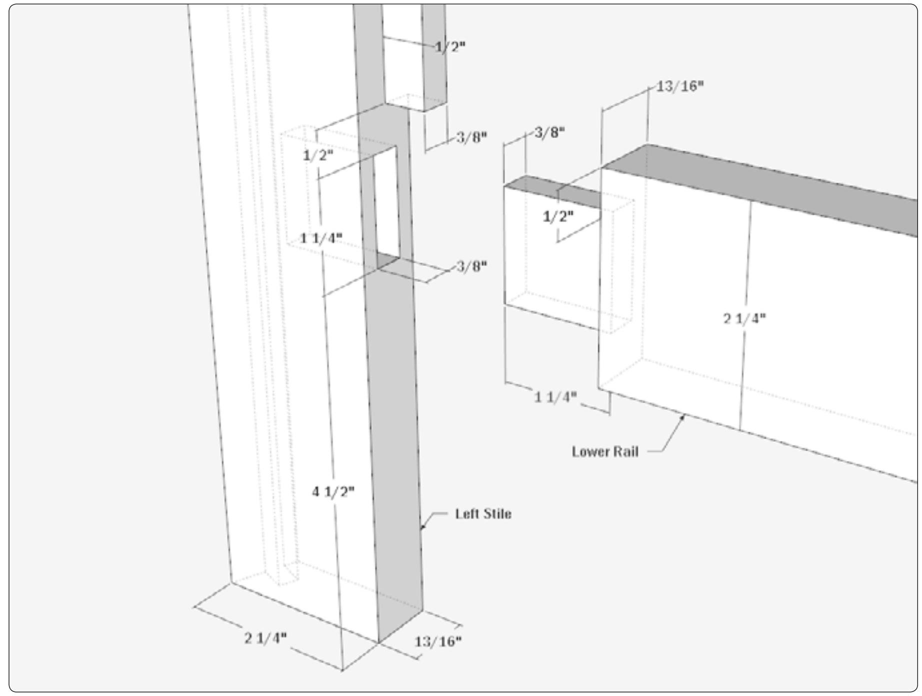


Figure 24. *Dimensioned details of the lower joint in the carcase frame.*

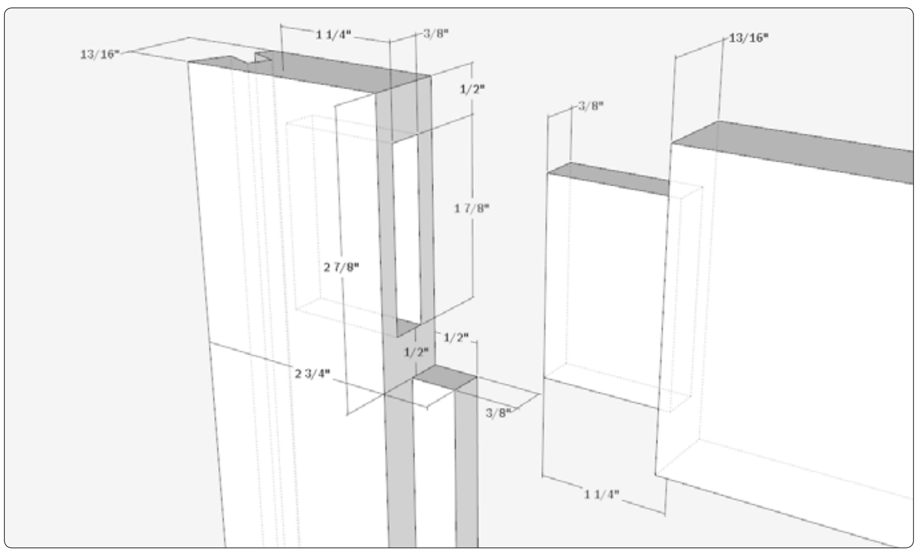


Figure 25. *Dimensioned details of the upper joint in the carcase frame. Only the left-hand stile has a rabbet on the inside edge.*

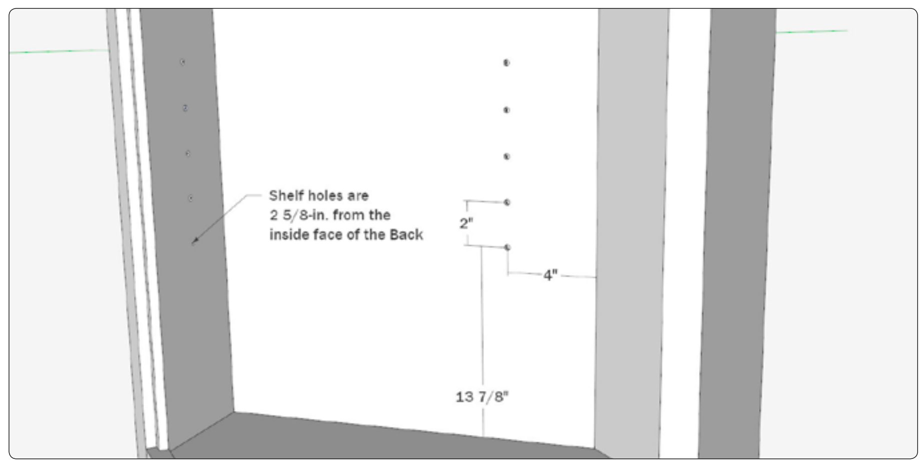


Figure 26. *Make ¼-in.-dia. holes ¼ in. deep in both the back and corner post components. The holes are spaced 2 in. apart, beginning 13⅞ in. from floor level.*

the left-hand stile component for editing. Draw a ⅜-in. by ½-in. rectangle, then use the Push/Pull Tool to extend the rectangle until it meets the top of the bottom rail. See Figure 22.

Step 7 There are several evenly spaced shelf-support holes on the back and the corner post. Follow the dimensions in Figure 26 to place guidelines for the centers of the holes, then use the Circle and Push/Pull Tools to create ¼-in.-dia. holes ¼ in. deep to accommodate the shelf-pin hardware.

Step 8 The carcase bottom and top are identical pieces. Create one within the assembly and copy it. I chose to draw the bottom in position, but you could just as easily draw the top and copy it instead.

Place a guideline 4 in. off the floor to locate its bottom edge. Use the Line Tool to trace over the guideline and continue around the carcase parts to complete the face. See Figure 27. Double-click on the face and make it a component. Use the Push/Pull Tool to make the component 1 in. thick. Make a copy and move it up until it is flush with the top of the case.

Margon specifies #8 x 1½-in. flat-head wood screws to fasten the top and bottom components in place. I've shown spaced screw holes that are 3⁄16 in. in diameter on the respective carcase parts, 4½ in. from the floor and ½ in. from the top edge. Molding covers the screw heads.

This completes the building of the lower carcase structure.

The next steps require more detailed dimensional information, which you will find in the illustrations on the next two pages.

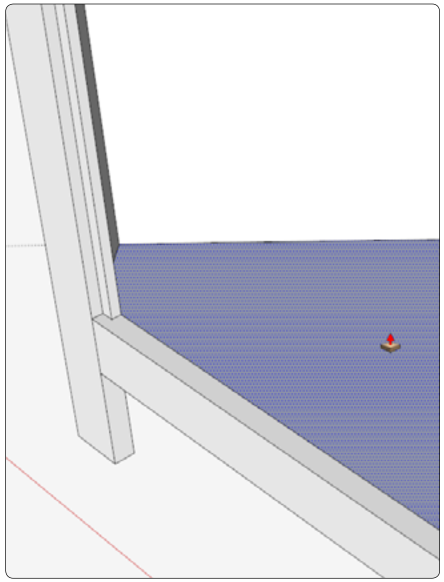


Figure 27. *Create the bottom component.*

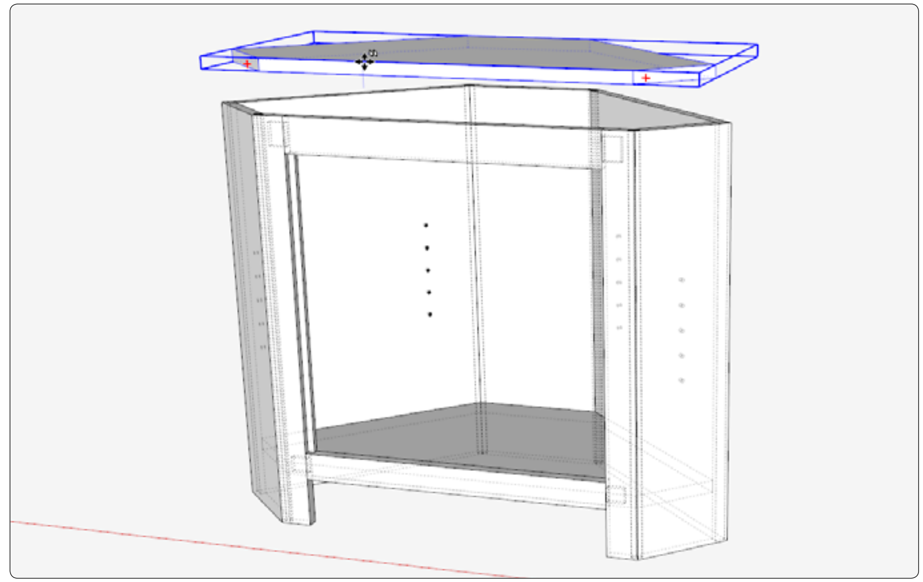


Figure 28. *Copy the bottom to the top of the finished carcase.*

Status Report

The drawing of the basic lower carcase structure is now complete. This would probably be an early milestone in the shop as well.

The case uses several joint styles, one being a beveled spline joint. It is not used very often in carcase construction, but it is common in small boxes.

A secondary wood such as yellow pine or poplar should be used for the backs and back post.

In the next steps, we'll apply the molding embellishments, the pilasters, a decorative foot, and the arched door to this structure.

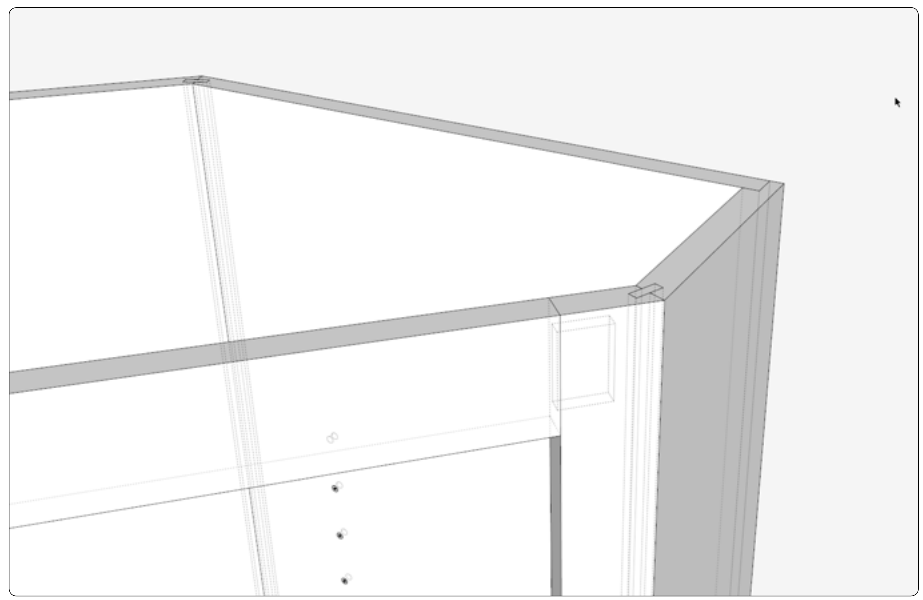


Figure 29. *Finished joints include mortise and tenon, beveled spline, and rabbet.*

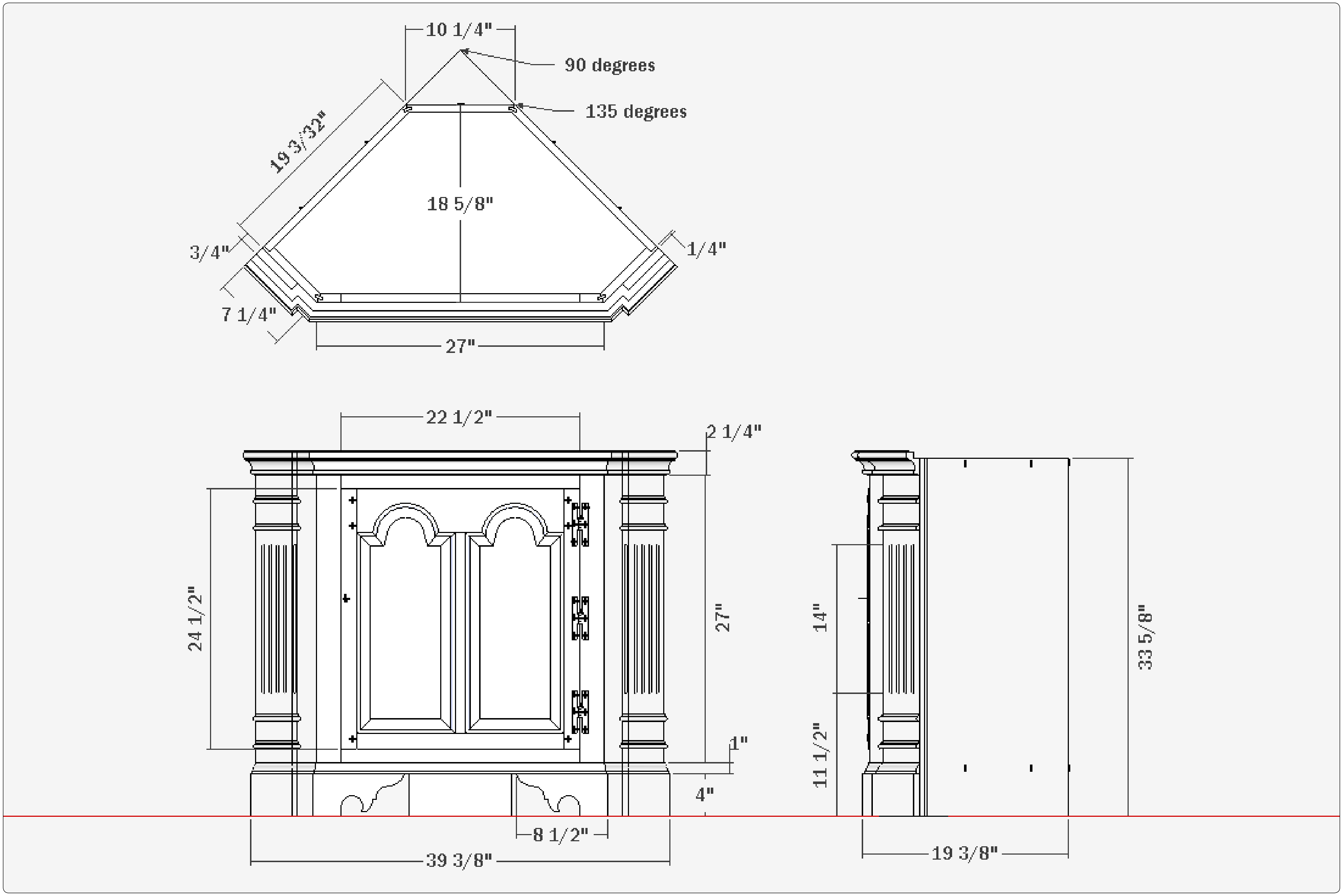


Figure 30. *The front, side, and top orthographic views of the lower cabinet, showing positions for the molding, hardware, and other embellishments.*

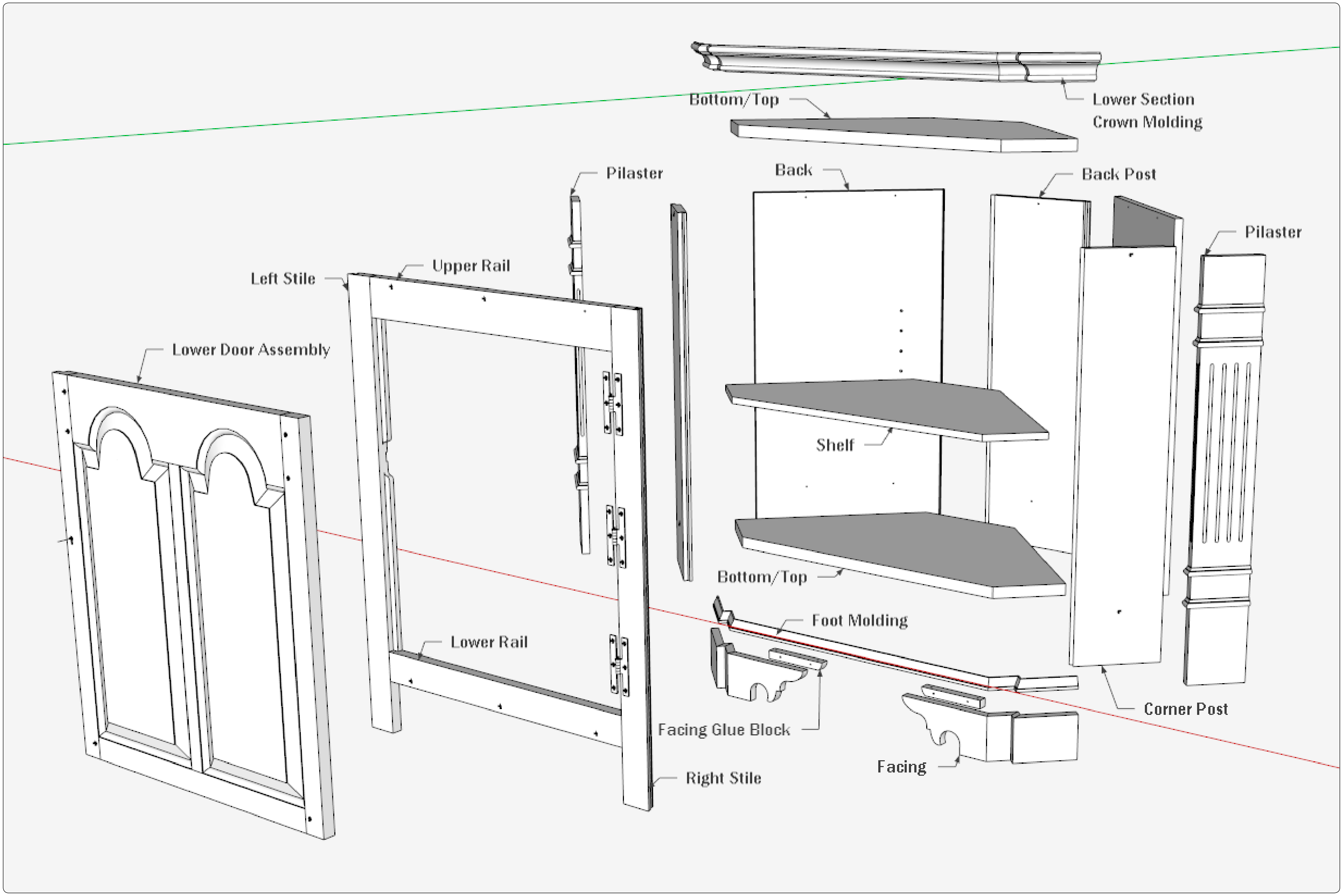
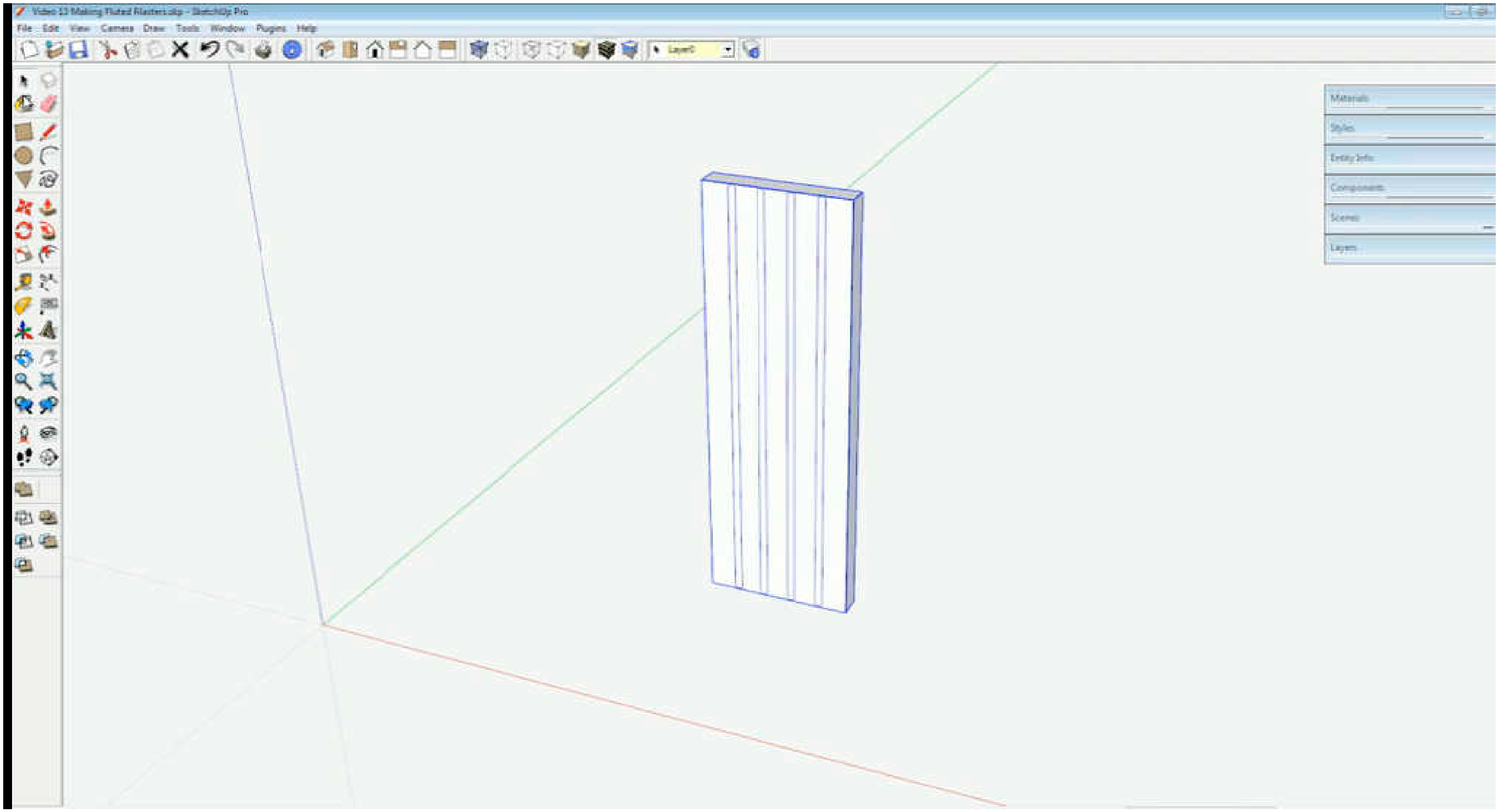


Figure 31. *An exploded view of the lower cabinet, showing the door, the moldings, and the facings that cover the carcase skeleton at the base.*

Video Tutorial: Making Fluted Pilasters

There are several ways to create flutes in SketchUp. In this video, I'll show the easiest way I've found that does not require the use of the Intersection function or a separate plug-in. After you create the rectangular pilaster component, you use the Scale Tool to increase the size of the component by a factor of 10. Then you position guidelines to denote the edges of the flutes. Finally, you use the Circle, Line, and Follow Me tools to extrude the flutes into the face of the pilaster.



Apply the fluted pilasters

The pilaster is a feature in classical architecture: a shallow rectangular pillar that gives the appearance of a supporting column. It can have a plain or fluted surface. Pilasters often flank a door frame or window opening, and they are used in traditional furniture design.

In this case, the pilasters are decorative, fluted, and divided with horizontal strips of molding. This piece begins as a simple plank of wood. Vertical ¼-in.-wide (or diameter) flutes are carved into the front face and the edges. The moldings are mitered, then glued and nailed in place.

Step 9 It's easiest if you draw the pilaster away from the rest of the model, working on axis. Once you have completed the pilaster, you can move and rotate it to connect it to the carcase.

Using the dimensions in Figure 32, make the center section of the pilaster: a piece ¾ in. thick, 4¾ in. wide, and 14 in. long. Make the piece a component. This is only the portion with the flutes. You will create it first, then use the Push/Pull Tool to make the pilaster its full length.

Divide the top edge into five equal segments, as shown in Figure 34. (Dividing a line is explained on page 32.) Draw vertical lines at the ends of the line segments. These form the centerlines of the four flutes on the front face. Draw another vertical line down the center of the edge. See Figure 35.

Close out of the edit-component mode, then click once on the component to highlight it. Choose the Scale Tool, which generates small squares at the corners and midpoints of the shape. Hover the cursor

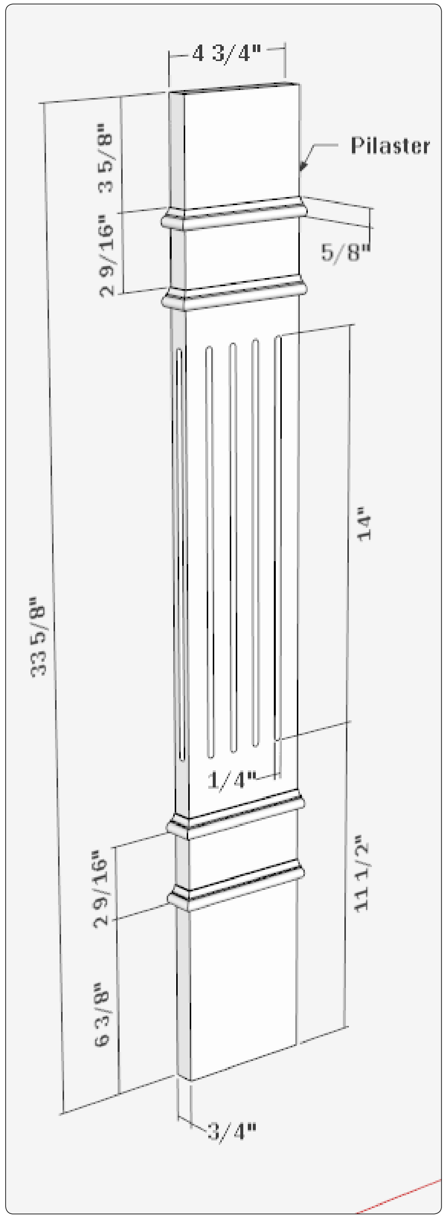


Figure 32. *Key dimensions for the lower pilaster.*

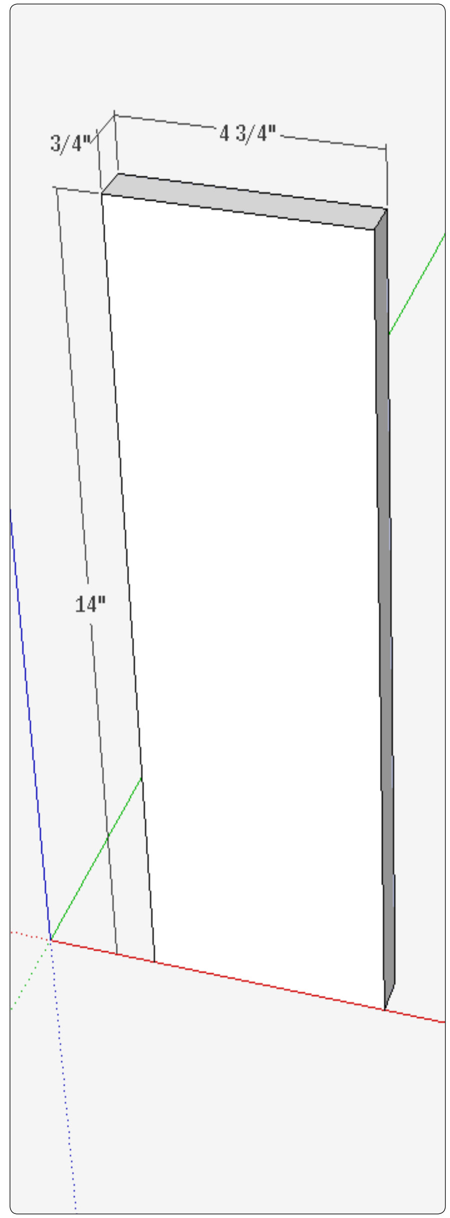


Figure 33. *Make the middle section of the pilaster, where the flutes are carved.*

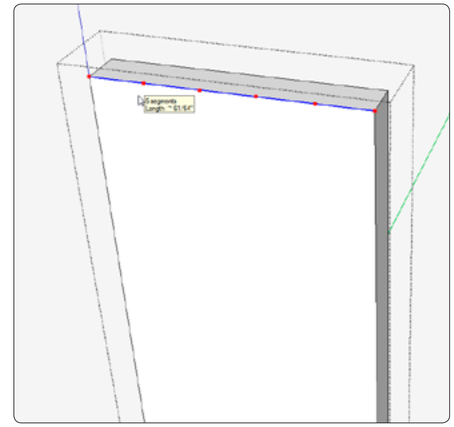


Figure 34. *Divide the top edge into five equal segments.*

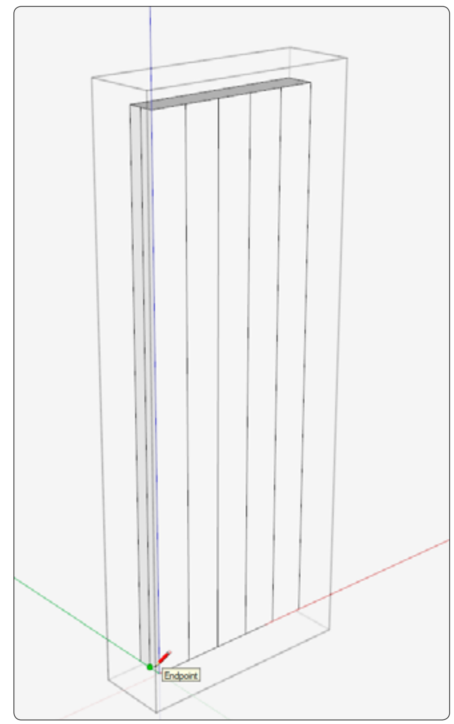


Figure 35. *Draw vertical lines at the end of the line segments and down the edge.*

near the square at a bottom corner, then move to a square at the opposite corner of the opposite end. Be sure the label next to the cursor reads, "Uniform scale about opposite point." That ensures that the component will grow in proportion and not simply be stretched. Begin moving the cursor to enlarge the shape, then type 10 and press Enter. This scales up the size of the pilaster by a factor of 10. See Figure 36. Scaling up allows SketchUp to render the small curves of the flutes smoothly.

Step 10 As shown in Figure 37, place a guideline 1¼ in. from the top edge of the pilaster. Place a similar guideline up from the bottom edge of the pilaster. This dimension of 1¼ in. is ten times the normal size of a flute with a ⅛-in. radius. The guidelines locate the center of the circles that make the end shapes of the flute. After drawing the circle, draw a temporary horizontal line along the diameter, then delete the bottom half of the circle and the diameter line. Repeat these steps at the bottom end.

As shown in Figure 37, draw vertical lines to connect the ends of the half-circles to finish the flute shape. Keep the vertical line down the center of the shape.

Draw a circular path for the Follow Me Tool on the top edge of the pilaster, as shown in Figure 38. Select the path, choose the Follow Me Tool, and click on the half-shape of the flute. Figure 39 shows the result. Click on the protruding shape of the flute and tap the Delete key. This removes part of the flute so that it is flush with the face of the pilaster. You may need to delete the centerline and redraw a vertical line, then delete a face in order to make the flute appear completely.

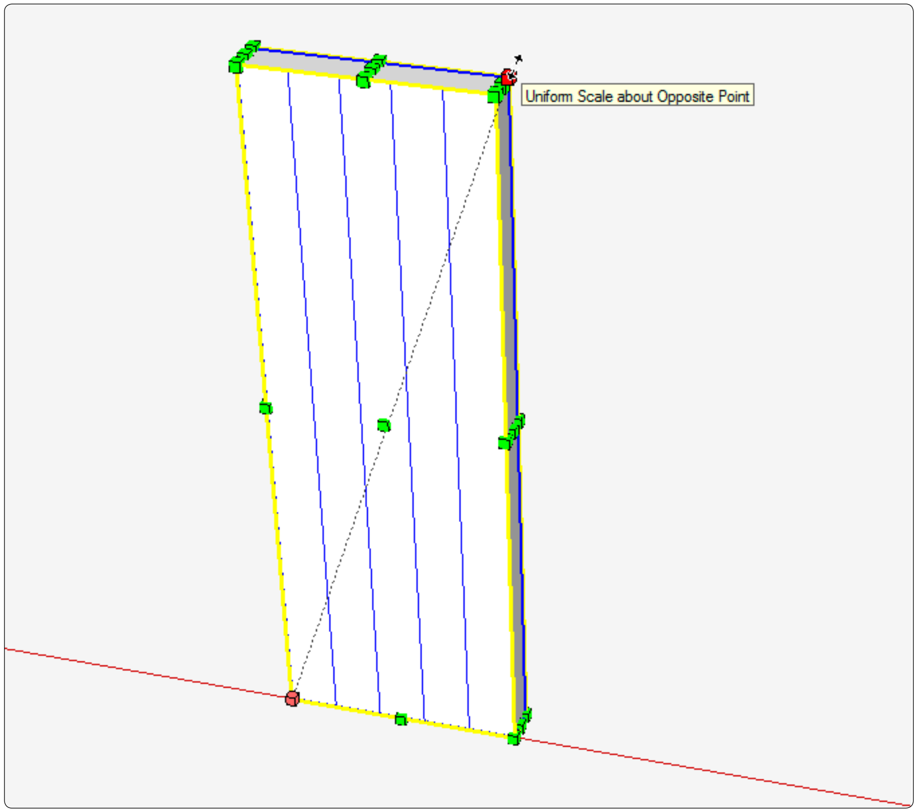


Figure 36. *Scale the piece up by a factor of 10 before drawing the flutes.*

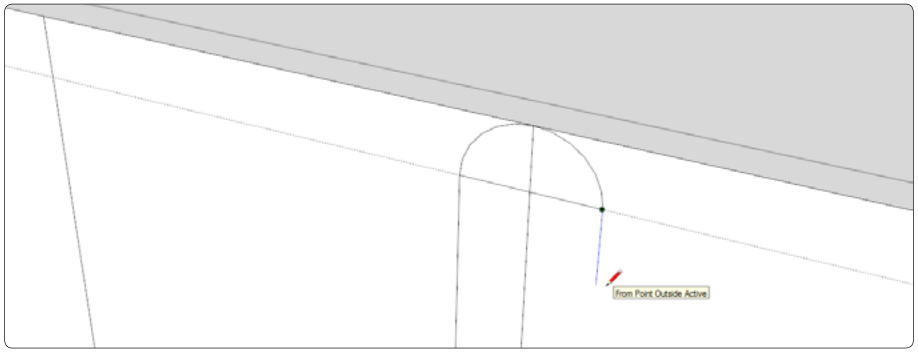


Figure 37. *Draw the semicircular flute shapes at each end of the pilaster.*

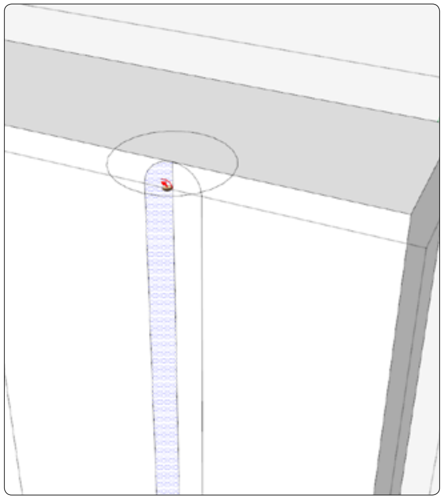


Figure 38. *Place a path, then use the Follow Me Tool to generate the flute.*

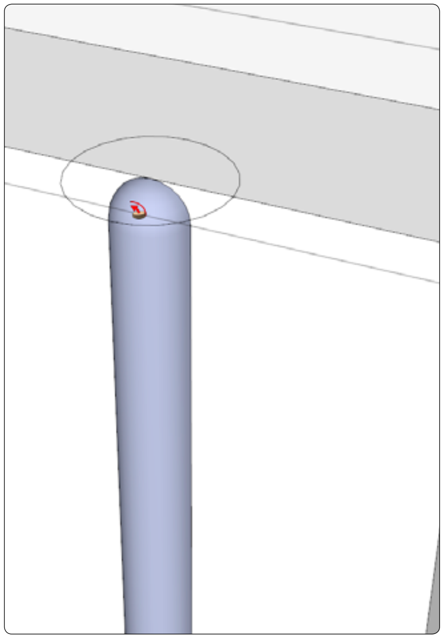


Figure 39. *The results of the Follow Me extrusion on the flute shape.*

Reverse the face on the flute if necessary. Delete the Follow Me path, too.

Step 11 Use the Select Tool to select the entire flute, as shown in Figure 40. When doing this, orbit around so that the pilaster is oriented more or less vertically. Otherwise, you may select parts of the pilaster you don't want. Check your selection by changing the view to X-Ray.

Place copies of the flute on the remaining centerlines. Use the very tip of the flute as the grab point. As shown in Figure 41, rotate the end flute 90 degrees to place it properly.

When you have placed all the flutes, highlight the entire pilaster shape and use the Scale Tool to reduce it to one-tenth its size (type 0.1 and press Enter once you begin scaling), which brings it back to its proper dimensions.

Step 12 As shown in Figure 32, the bottom of the flutes is located 11½ in. from the bottom edge of the pilaster. Place a guideline at that distance below the end of the flutes. See Figure 42. Use the Push/Pull Tool to extend the end of the pilaster until it meets the guideline. Erase extraneous lines that appear on the face.

The total height of the pilaster is 33⅝ in. Place another guideline that distance from the bottom edge. Use the Push/Pull Tool again to bring the top edge of the pilaster to its final length.

Step 13 Four small molding strips adorn the face and one edge of the pilaster. Margon's book includes a drawing of all the molding profiles for the corner cupboard. See Figure 43. You can scan that image or convert this page of the PDF into a .jpg or .png file. Import the picture as an image, square it up to align with the axes, and scale to full size. (Scaling an image is covered on page 71.) The molding profiles are drawn on a grid of ¼-in. squares, which will help you size the image in SketchUp.

With the Line and Arc Tools, trace over the pilaster molding profile, as shown in Figure 44. Make the shape a component. Place guidelines on the pilaster for the locations of the bottom edge of the moldings. Figure 32 shows those locations.

Place the molding profile on the first guideline, as shown in Figure 45. Draw a path for the Follow Me Tool that turns the

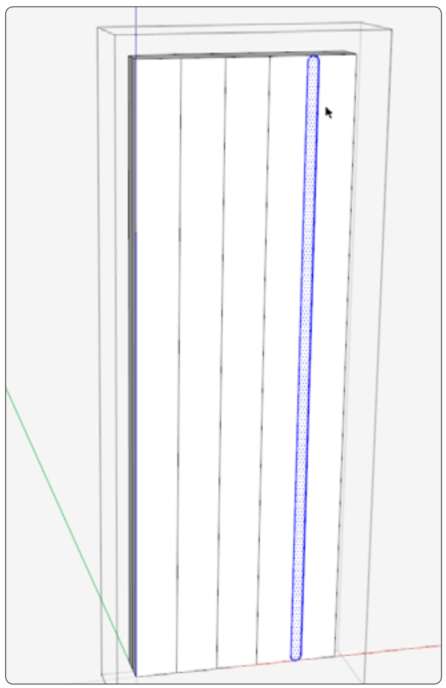


Figure 40. *Select the entire length of the flute in order to copy it.*

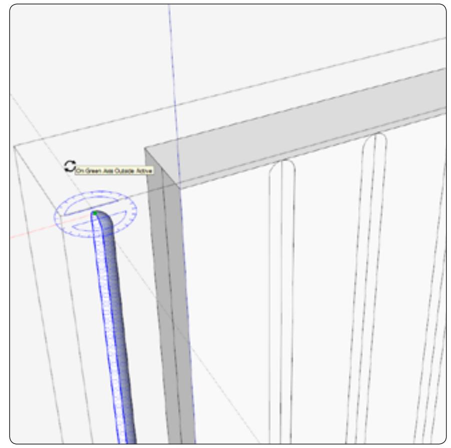


Figure 41. *Copy the flute to the other four locations. Rotate the end flute 90 degrees.*

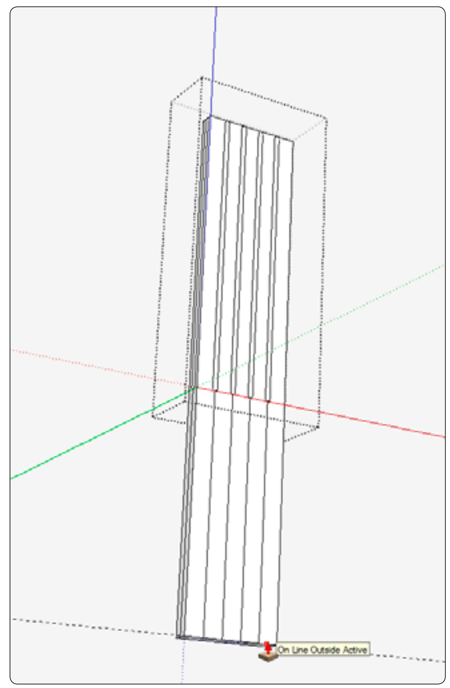


Figure 42. *Extend the bottom edge 11½ in. to create the bottom of the pilaster.*

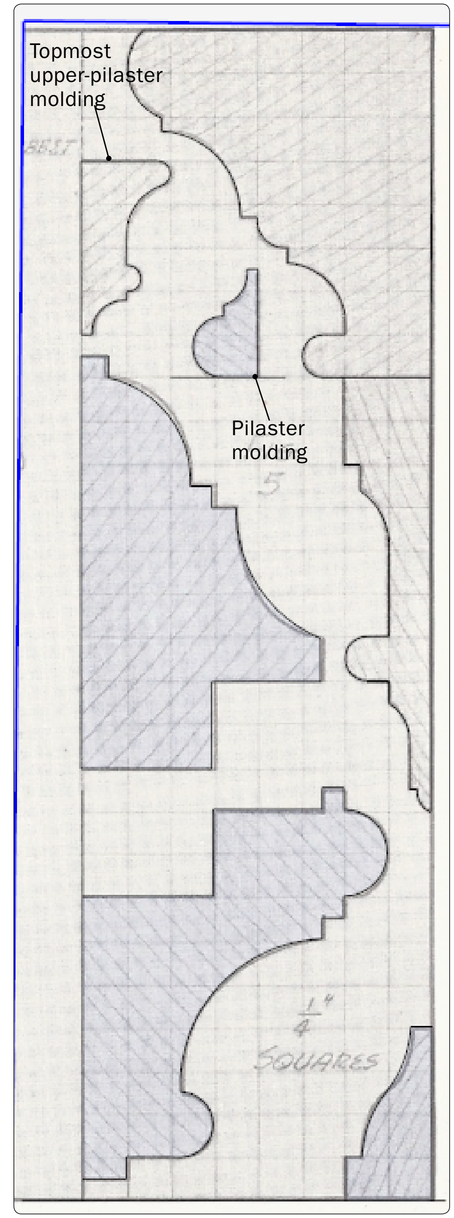


Figure 43. *The scanned image of molding profiles from Margon's book.*

corner across the front edge. Select the path and choose the Follow Me Tool. Right-click on the molding profile, open the component for editing, and click the mouse on the profile. This generates the molding shown in Figure 46. Copy the molding three times and move the copies to the other guidelines. See Figure 47.

Step 14 Use the Move/Copy Tool to grab the pilaster at its top back corner and connect it to the front corner of the stile, as shown in Figure 48. Choose the Rotate Tool and click at the corner where the pilaster meets the carcase. Click on the back edge of the pilaster to begin the rotation. Rotate the pilaster toward the carcase and click on the front edge of the corner post to end the rotation. See Figure 49. Move the pilaster along the corner post until the back edges of the two components are flush.

Copy the pilaster, execute a flip along command, and move it to the other side of the carcase. You'll see that the pilaster is not positioned properly, the result of rotating the original. Use the Rotate and Move/Copy Tools to maneuver the copy into its proper position. See Figure 50.

Create the front facing

The front facing at the foot of the lower cabinet consists of the five parts shown in Figure 51. I added a glue block behind the facing, even though Margon's plan does not show one. I think it is necessary to properly support the facing. Step 16 shows where to place the block.

Step 15 Import an image of the scroll-cut shaped facing, as shown in Figure 52, to

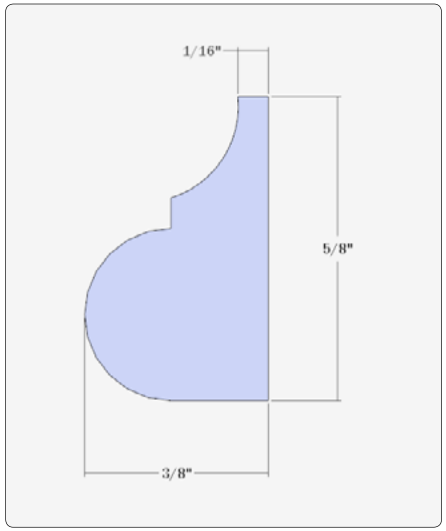


Figure 44. *Trace over the scanned image of the pilaster molding.*

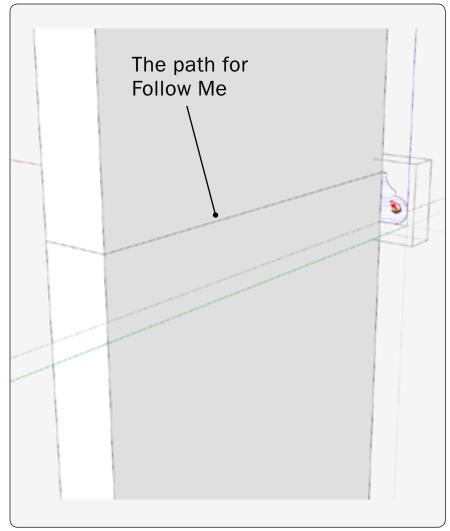


Figure 45. *Place the molding shape at the guideline on the pilaster and draw a path.*

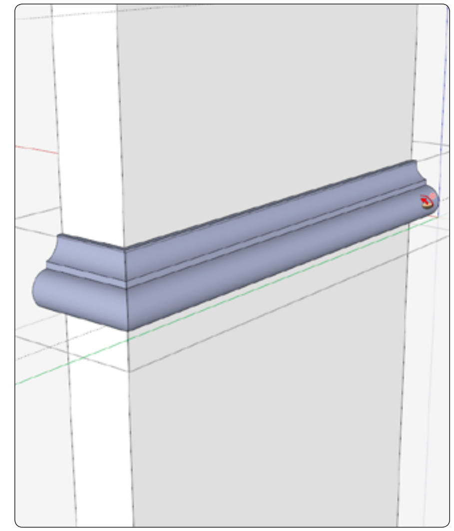


Figure 46. *The results of the Follow Me. Reverse the faces to get the proper color.*

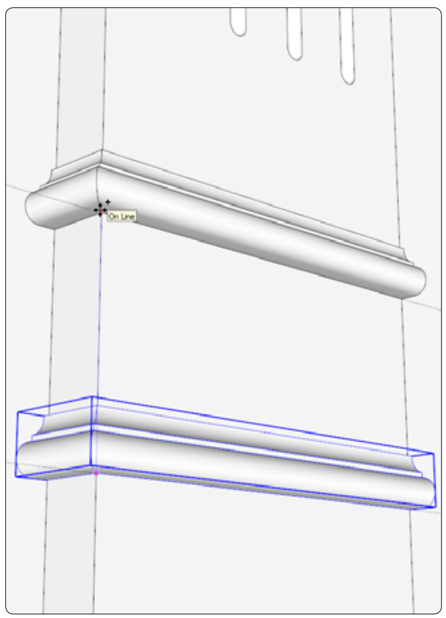


Figure 47. *Copy the molding to the other three locations on the pilaster.*

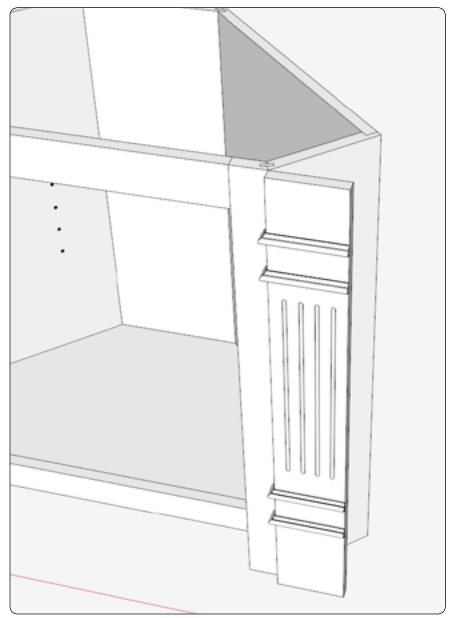


Figure 48. *Connect the pilaster to the carcase at their corners.*

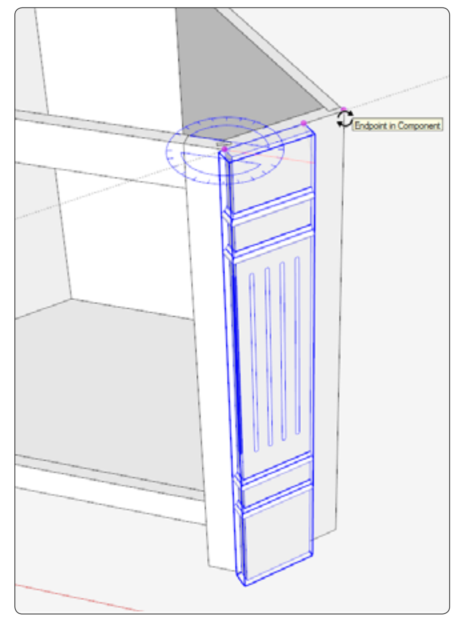


Figure 49. *Rotate the pilaster and move it to the rear corner.*

create it. (Use Figures 4 or 52.) The shape is 4 in. high, and 8½ in. long. Before giving the shape thickness, copy it, move it to the carcase assembly, and make it a component. Place the shaped facing where the front stile and corner post meet, as shown in Figure 53. Make the facing shape ¾ in. thick.

To create the miter joint on the end of the shaped facing, use the Protractor Tool to place a guideline for the angle of this joint, which is half of 45, or 22.5 degrees. See Figure 54. Draw a line over the angled guideline and push out the waste, as shown in Figure 55. Shift the facing to the left to position the miter joint at the corner of the carcase.

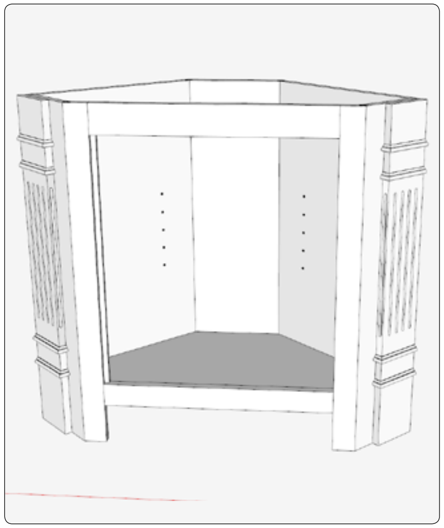


Figure 50. *Copy the pilaster and position it on the other side of the carcase.*

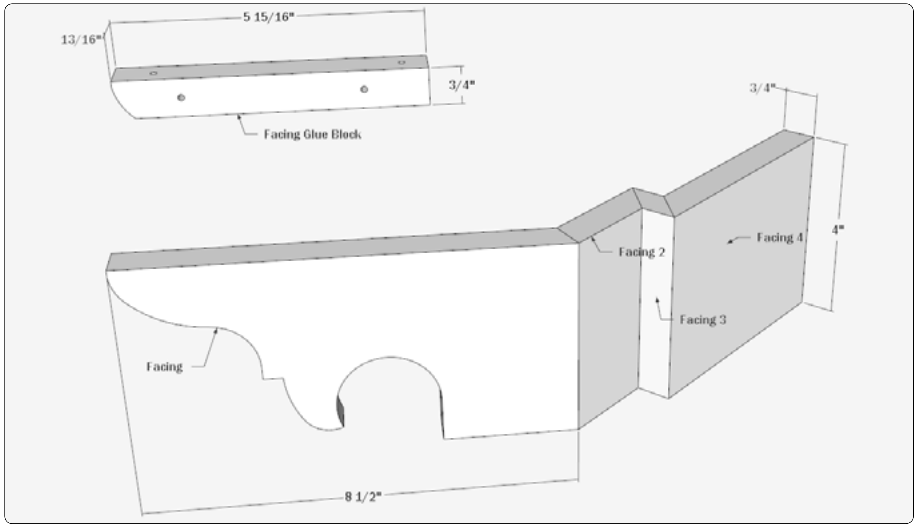


Figure 51. *The parts of the facing at the foot of the lower carcase.*

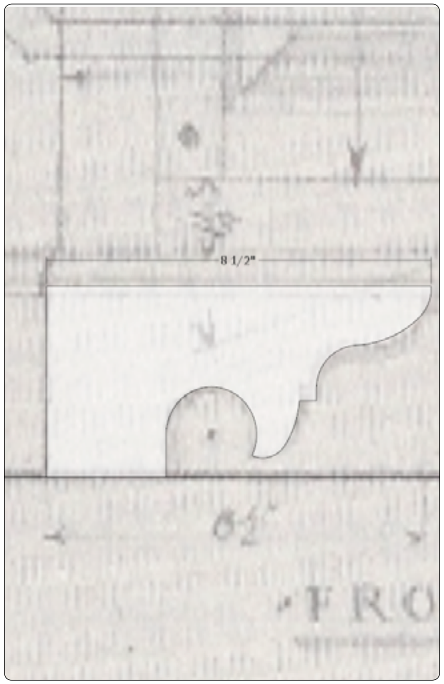


Figure 52. *Trace over the scanned image of the facing shape.*

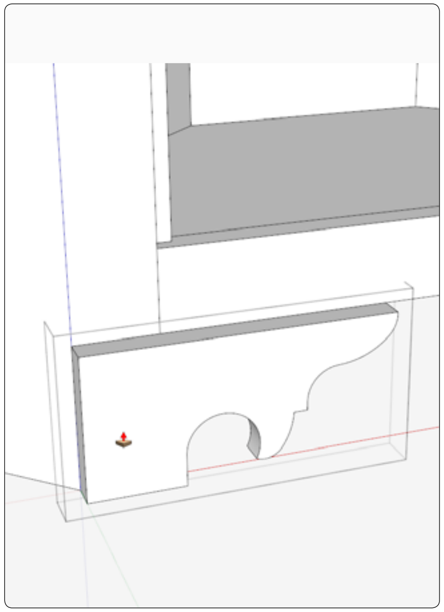


Figure 53. *Place the facing shape on the carcase front stile and pull out its thickness.*

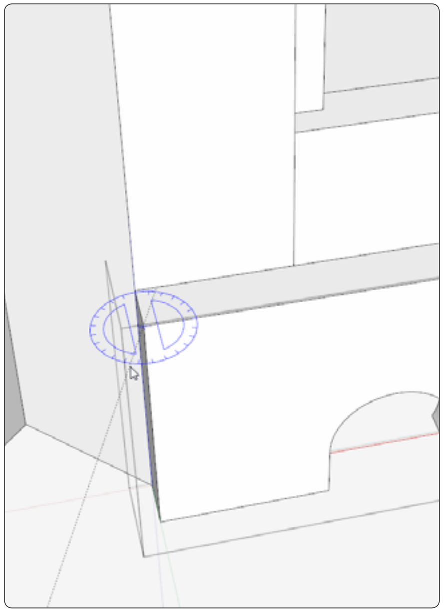


Figure 54. *Create the angle for the miter joint on the end.*

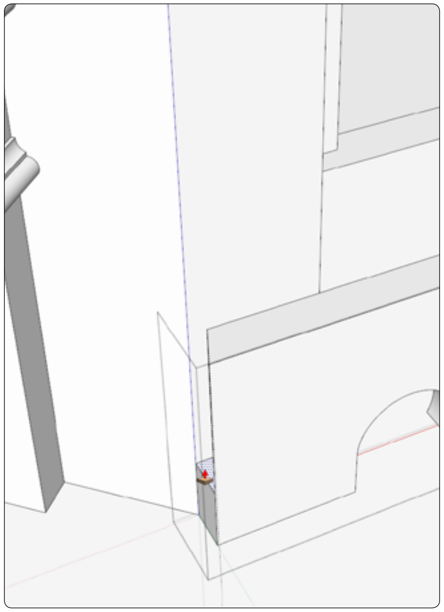


Figure 55. *Remove waste to make the miter joint; move the facing to the carcase corner.*

Step 16 To create the remaining facing pieces, I recommend using the Follow Me Tool. This requires a path across the carcase 4 in. off the floor. Place guidelines, then trace over them with the Line Tool to create the path. See Figure 56.

Draw a 4-in. by ¾-in. rectangle at the back end of the pilaster and make it a component. Select the path, choose the Follow Me Tool, right-click on the rectangle, pick Edit Component, and click on the face of the rectangle. The results are shown in Figure 57. In the shop, this component is actually three separate pieces mitered at the ends. Draw the miter joints on the top and bottom edges of the component, as shown in Figure 58.

The Follow Me extrusion stopped short of closing the gap at the miter connection to the shaped facing. To close that gap and create the miter, select the front edge of the facing, then choose the Move/Copy Tool, click on the front edge and move it over to touch the edge of the shaped facing. See Figure 58. Reverse colors if necessary to change the faces to white.

Move a copy of the facing component forward to check that these procedures worked properly. See Figure 59. You could convert this single component into three separate components, but that's probably not necessary to make them in the shop.

Create the facing glue block, using the dimensions in Figure 51. Position it as shown in Figure 60.

Finally, copy all the facing parts and move them to the opposite side of the carcase, flip them along the red direction, and move them into position on the front face of the carcase.

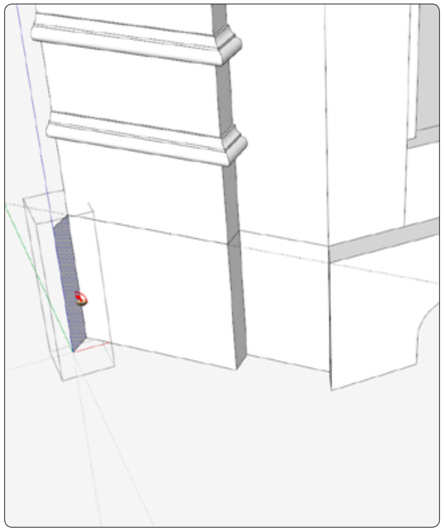


Figure 56. *Create a path for the Follow Me Tool and the rectangular face to extrude.*

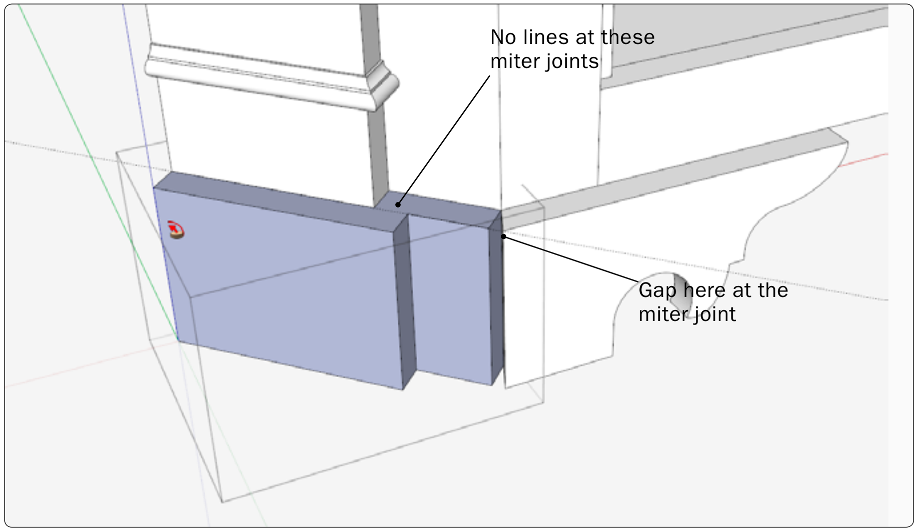


Figure 57. *The results of the extrusion. Note the gap at the miter joint with the shaped facing. Also note that there are no miter joint lines at the corners of the pilaster.*

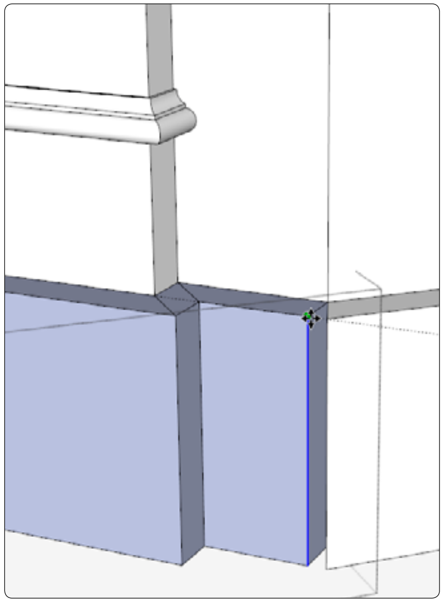


Figure 58. *Use the Move/Copy Tool to close the miter gap.*

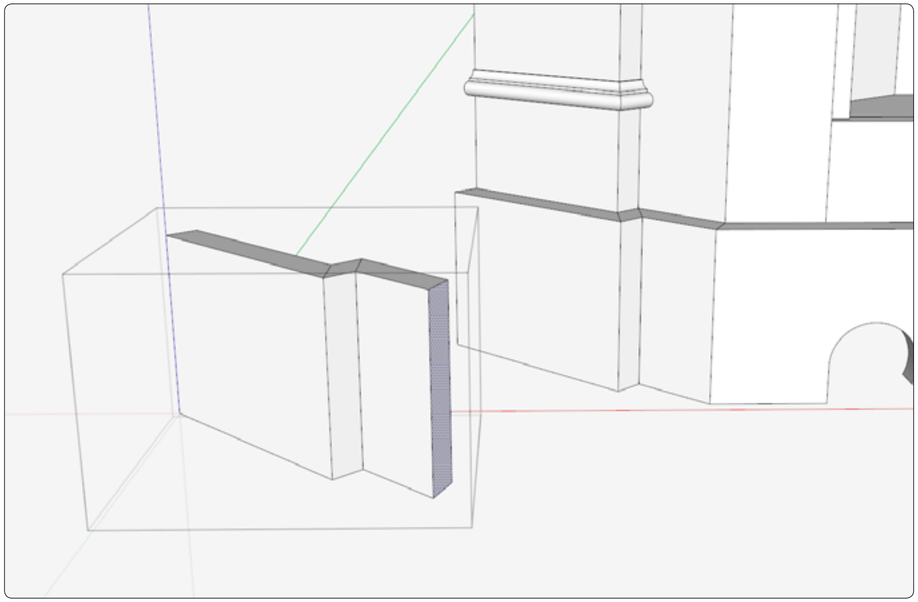


Figure 59. *Pull a copy of the facing pieces forward for inspection. Check that your procedures have worked properly. Reverse faces if necessary.*

Step 17 This cabinet has a small shoe molding running along the top of the facing. Figure 61 shows the molding profile. Create it either by importing an image or (since it is relatively simple) drawing it from scratch.

Extrude the molding with the Follow Me Tool, as you did to make the pilaster moldings. As shown in Figure 62, draw lines over the front top edge of the facing pieces to create the path for the Follow Me Tool. These lines will not be part of the facing components; you will delete them later. The path goes from end to end, so continue them all the way across the front and over the facing on the opposite side.

Select the path, choose the Follow Me Tool, right-click on the molding profile, select Edit Component, then click on the face of the profile. See Figure 63. The results are shown in Figure 64. Reverse the molding color if necessary. Delete the lines for the Follow Me path.

You could split the assembly into separate SketchUp components, but I don't find that helpful in the shop.

This completes the front facing.

Create the lower shelf

The lower cabinet holds one adjustable shelf, which rests on pins inserted into the holes in the carcase. There is a ⅛-in. gap between the edge of the shelf and the inside face of the carcase. The front edge of the shelf is inset ⅜ in. from the inside surface of the front stiles.

Step 18 Use the bottom/top component to create the lower shelf. Make a copy of the component, right-click on it, and choose Explode from the pop-up menu. Right-click

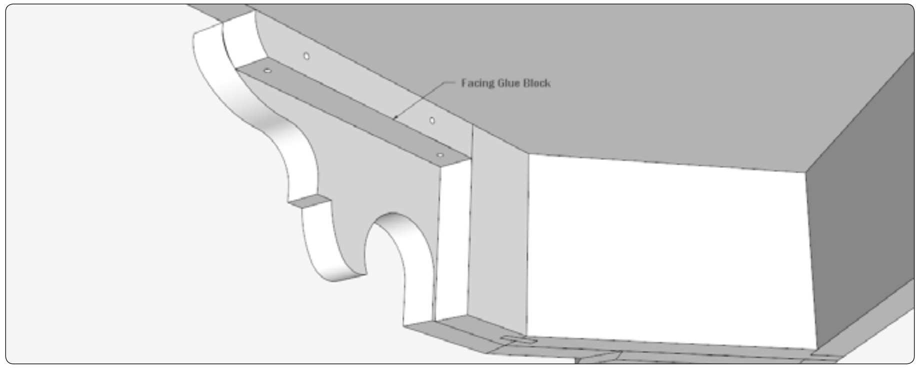


Figure 60. *Create the facing glue block and position it behind the shaped facing.*

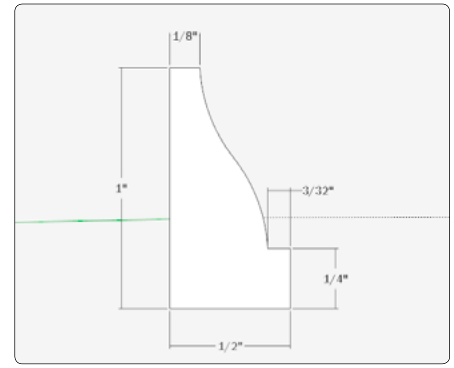


Figure 61. *The shoe molding profile.*

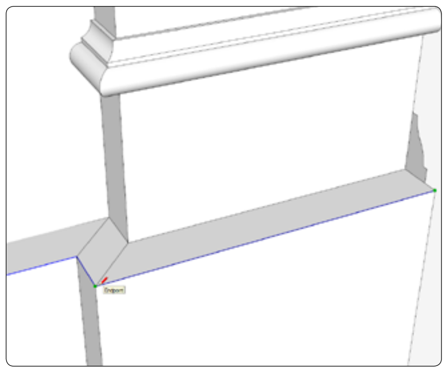


Figure 62. *Create a path for the Follow Me Tool along the front edge of the facing.*

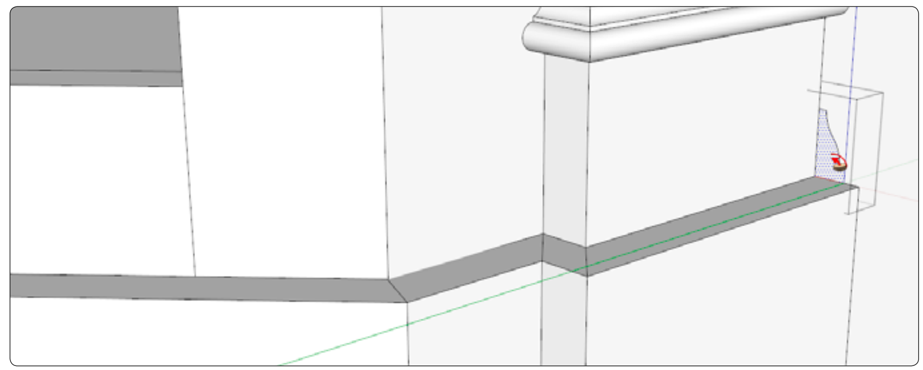


Figure 63. *Position the molding profile, select the path, and extrude the molding.*

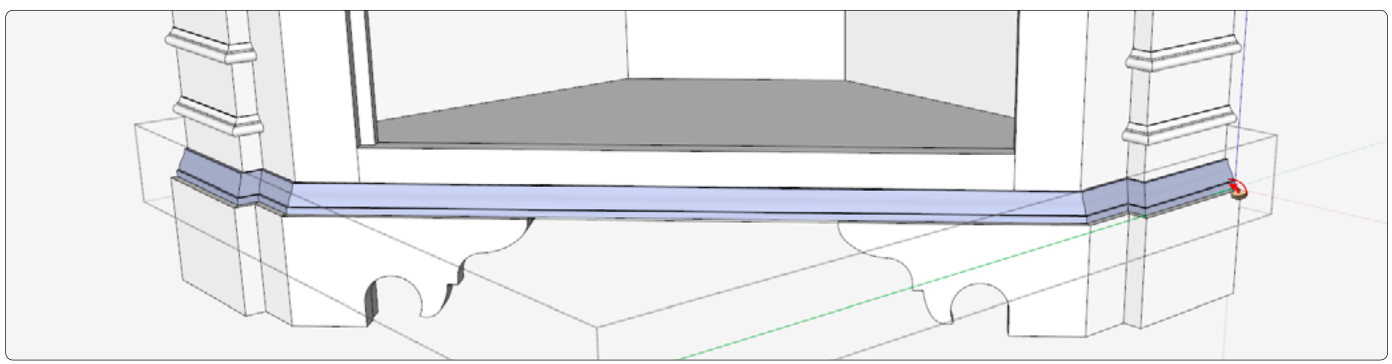


Figure 64. *The results of the Follow Me extrusion. The shoe molding is a single component. In the shop it will be individual mitered pieces. The blue color needs to be reversed in the model.*

again, choose Make Component, and give it a new name. The shelf is ⅝ in. thick, so use the Push/Pull Tool to reduce the thickness.

Step 19 Next, trim the shelf to create the gap between its edge and the carcase. Use the Offset Tool to create a ⅛-in. border around the entire top face of the shelf, as shown in Figure 65. Use the Push/Pull Tool to remove the material within that border.

Step 20 To make the inset at the front edge of the shelf, place a guideline ¼ in. from the front. Trace over it with the Line Tool, and use the Push/Pull Tool to remove the waste. See Figure 66.

Extrude the cornice molding

Margon's drawing of the cornice molding for the lower cabinet is shown in the lower left-hand corner of Figure 43. Trace over the shape as you did for other moldings, producing a shape like the one shown in Figure 67. The upper cabinet section has a complementary molding around its base, which sits inside the notch on the lower-cabinet crown molding.

Step 21 Connect the molding profile to the back top edge of the pilaster, as shown in Figure 68. Create a path for the Follow Me Tool by drawing a line along the front top edge of the carcase, running from the back edge of one pilaster to the back edge of the other. Be sure you have no components open for editing when you draw this path. It will be deleted later in the process.

Step 22 Select the path, choose the Follow Me Tool, right-click on the molding profile, choose Edit Component, and click on the profile face. See Figure 69.

This completes the construction of the lower carcase. You will create the paneled doors in the next section.

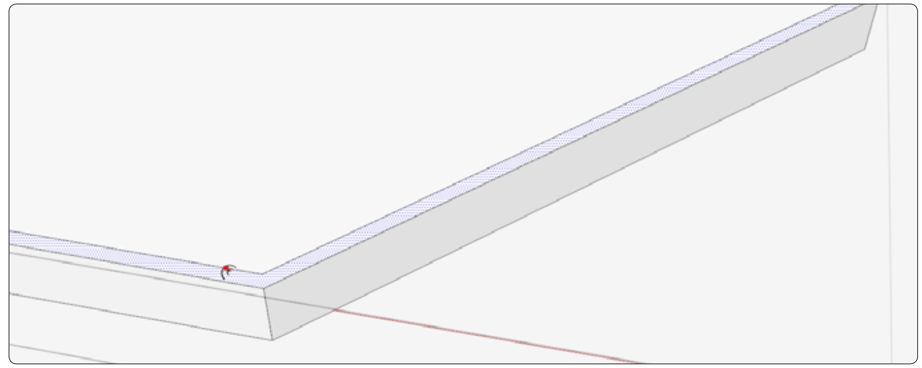


Figure 65. *Create a ⅛-in. inset for the shelf by using the Offset Tool.*

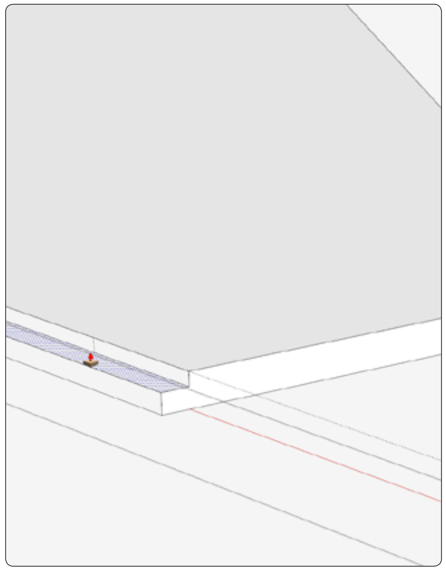


Figure 66. *Remove another ¼-in. slice from the front edge of the shelf.*

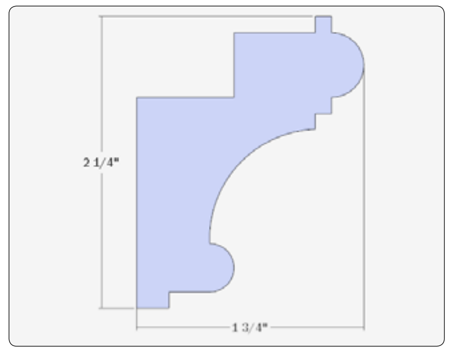


Figure 67. *Trace the profile shape for the crown molding.*

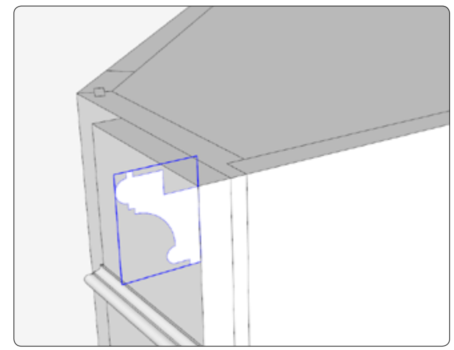


Figure 68. *Connect the profile to the back edge of the pilaster.*

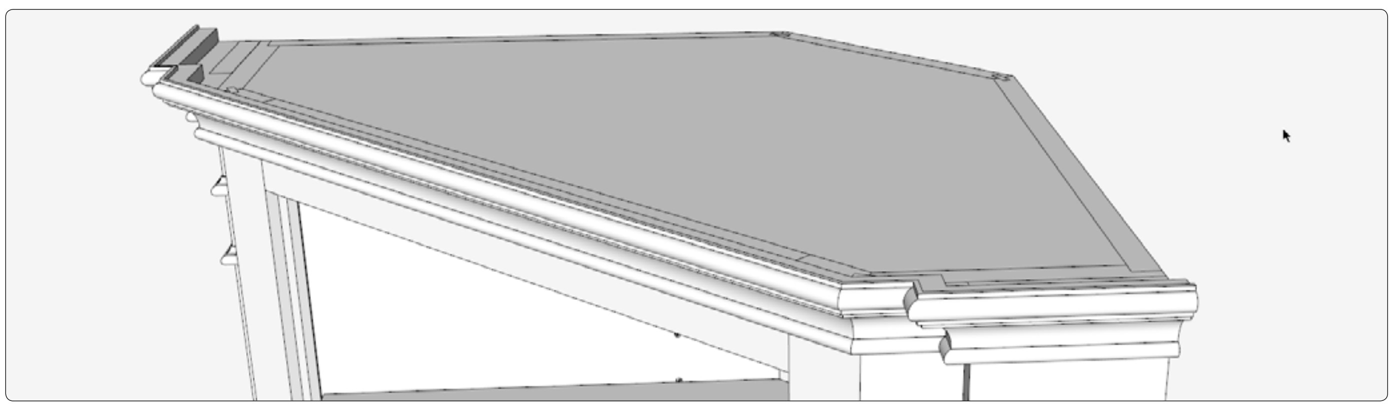


Figure 69. *The results of the Follow Me. The crown molding is a single component. In the shop, this will be assembled from individual pieces.*

Status Report

The lower cabinet section now has all of its applied decoration and molding. Since the last status report, we've added fluted pilasters, the lower facing, shoe molding, an interior shelf, and crown molding.

You've also made use of a variety of SketchUp tools. In addition to the normal Select, Line, Circle, and Push/Pull Tools, this section has required the use of the Scale, Offset, Protractor, and Follow Me Tools.

Figure 70 shows the current status of the cabinet. You'll build the door assembly next, which will complete the work on the lower cabinet.

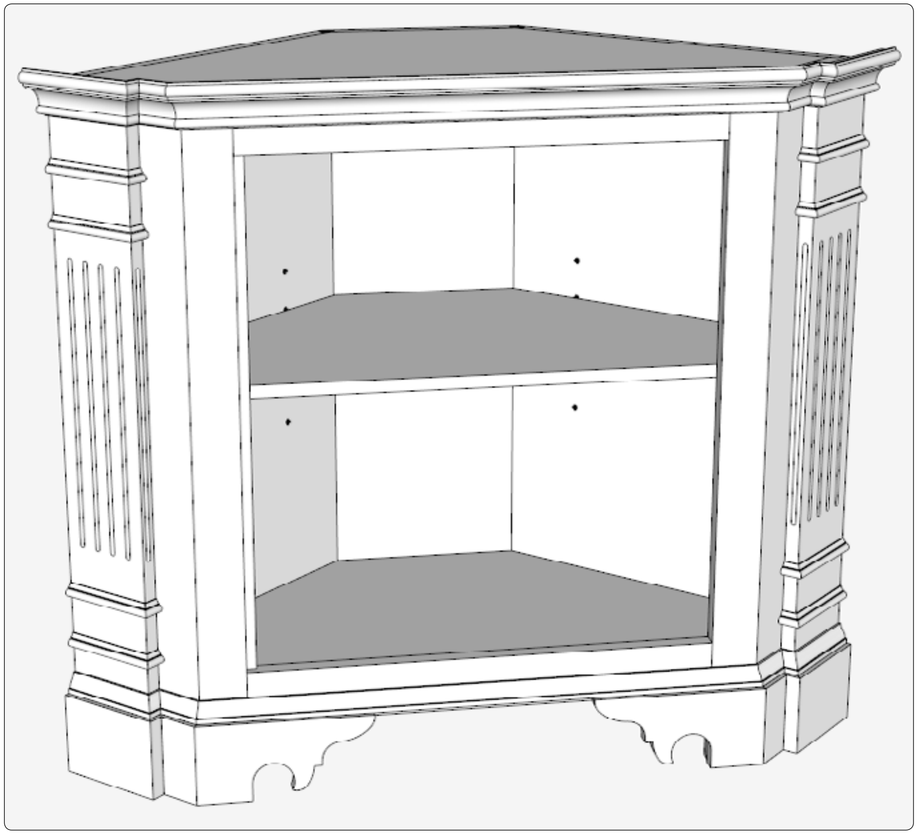


Figure 70. *The current status of the lower cabinet. The door is the last assembly required to complete this portion of the corner cabinet.*

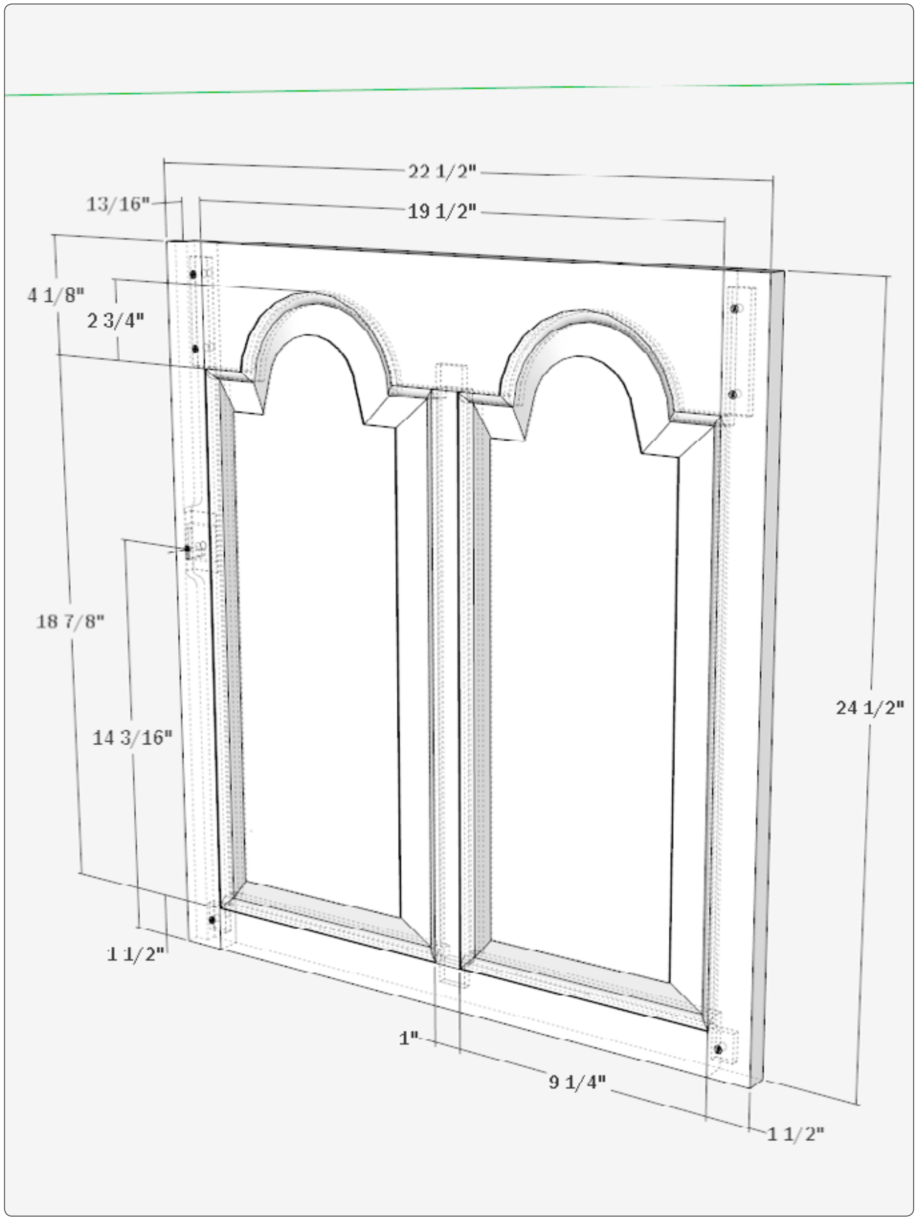


Figure 71. *Dimensions for the lower cabinet door assembly.*

Create the lower-cabinet door

The doors for the corner cupboard are probably the most difficult SketchUp assemblies in this book. The lower-cabinet door is arguably the simpler of the two.

Building it in the shop is also a challenge. Whether in SketchUp or the shop, it is not easy to make the fingernail molding on the stiles and rails with their coped joints. The arched tops of the door panels add to the difficulty.

However, working through the door assembly step by step in SketchUp will make it much easier in the shop. You'll see the details of the joinery, how the parts fit together, and what shapes and sizes to use. The beveled arches require intricate hand-tool work, but SketchUp makes that easier by generating full-size templates, perspective views, and critical dimensions.

The door panels float within grooves in the frame to allow for seasonal expansion and contraction of the solid wood. They need to fit snugly into a groove that is deep enough to accommodate the seasonal changes.

Margon provides helpful detailed design information on the doors. Figure 1 of this chapter shows one of his illustrations for this door and the upper door. His dimensions are comprehensive and consistent.

Step 23 The first steps in creating this door are very much like those shown for the wall cabinet in Chapter 3.

Begin by drawing a rectangle within the carcase door opening. I use this as a template for making the stiles and rails. Copy the rectangular shape and move it to the side. Draw guidelines to indicate the width of the rails and stiles, and trace over them

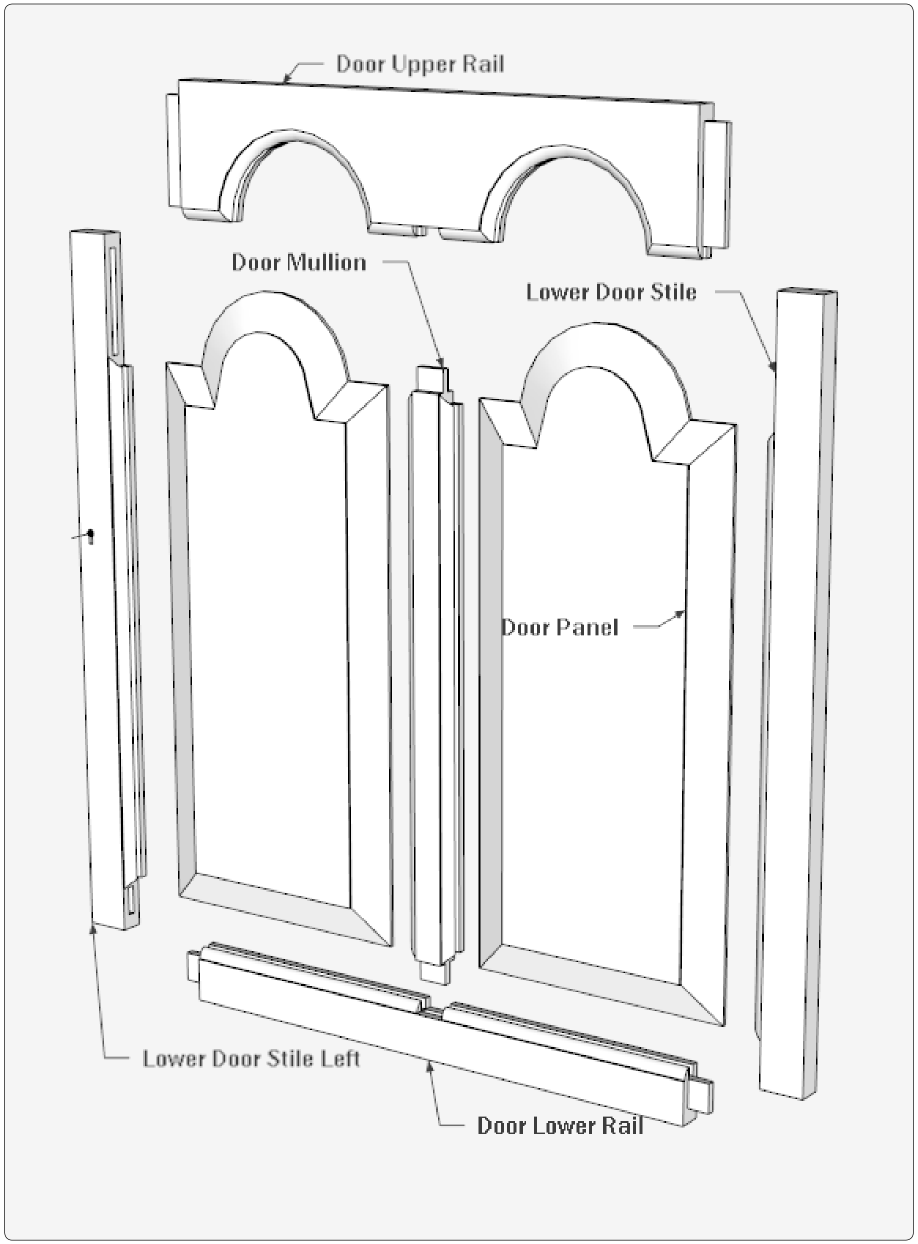


Figure 72. *An exploded view of the lower cabinet door.*

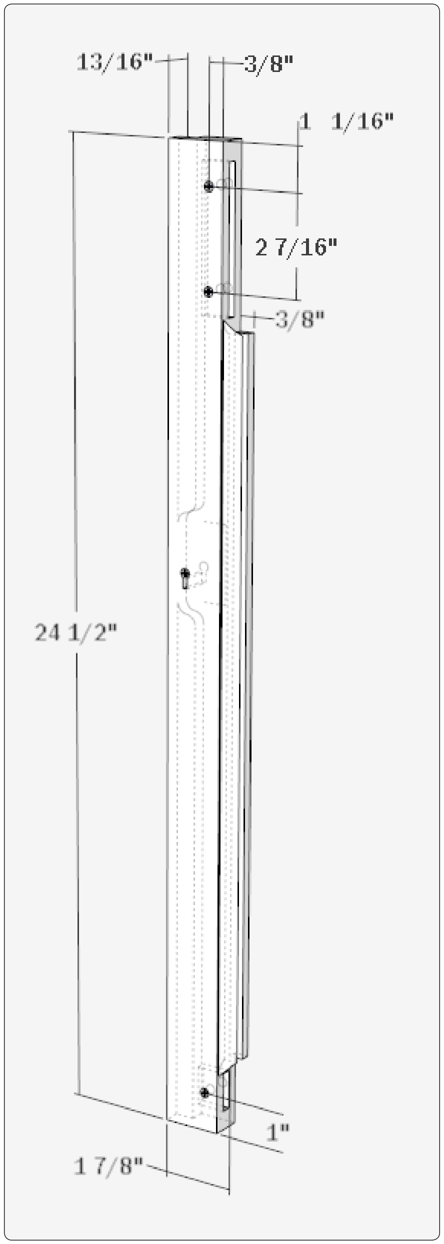


Figure 73. *Dimensions for the left door stile.*

with the Line Tool. Select the rail and stile shapes one by one from this outline and make them components. See Figure 75.

Step 24 Using the dimensions given in Figures 76, 77, and 78, edit each of these door components by making them 13/16 in. thick and shaping the mortise-and-tenon joints. See Figure 79. The 3/8-in.-deep molding and groove on the inner edges of the components will be appended in a later step.

Step 25 Create the arched cutouts in the upper rail. Figure 80 shows the radius as

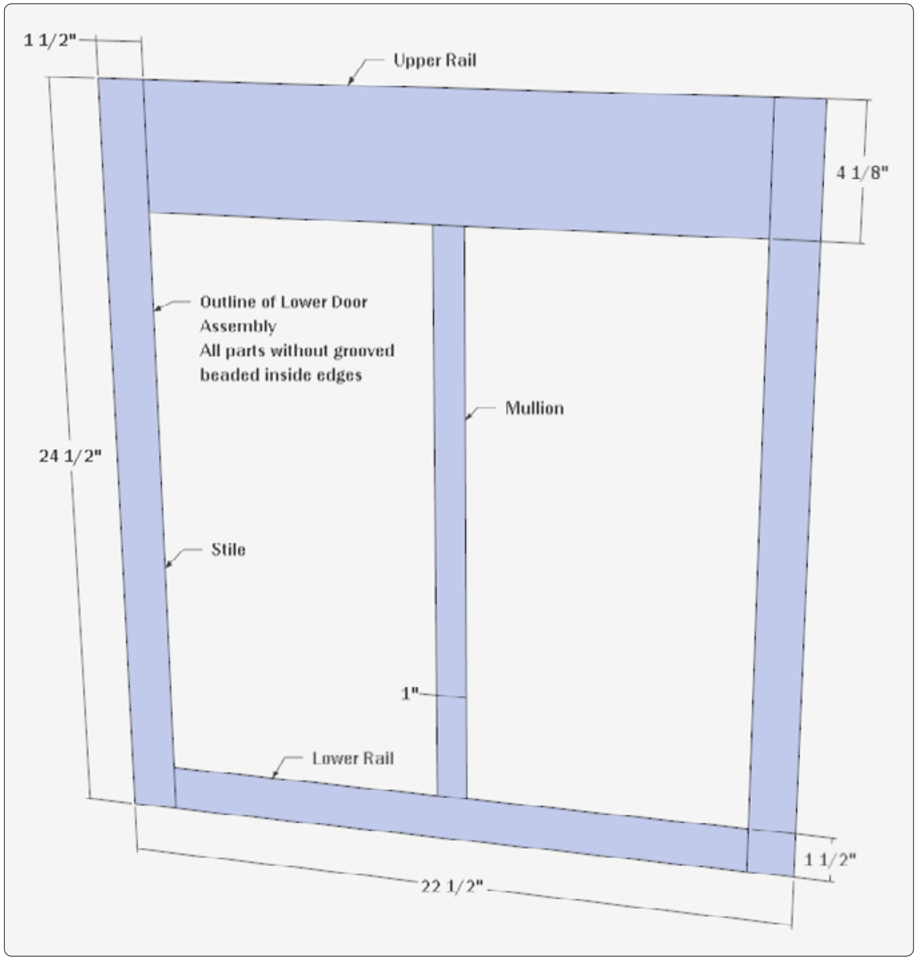


Figure 75. *Make a rectangular shape the size of the door opening and use it as a template to begin shaping the rails and stiles.*

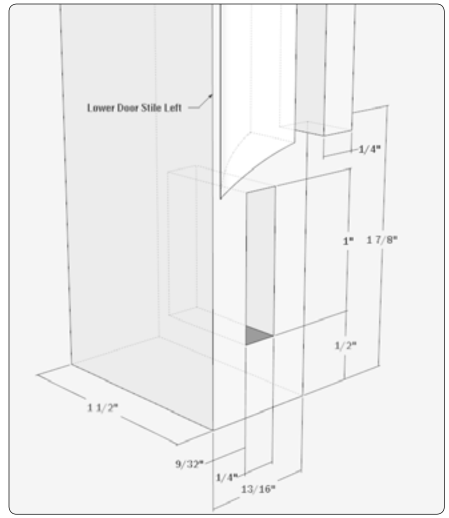


Figure 76. *The door stile's lower joint details and dimensions.*

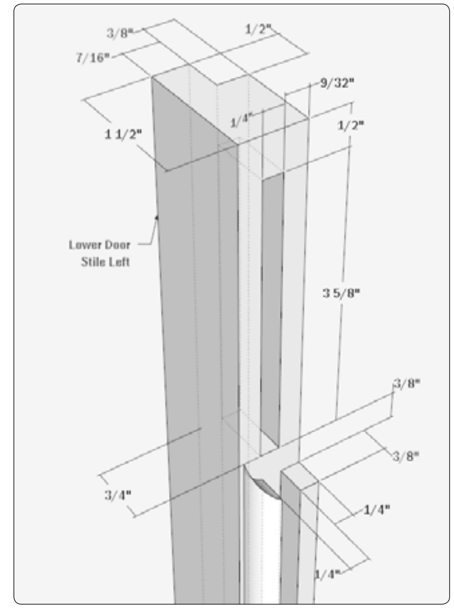


Figure 77. *The door stile's upper joint details and dimensions.*

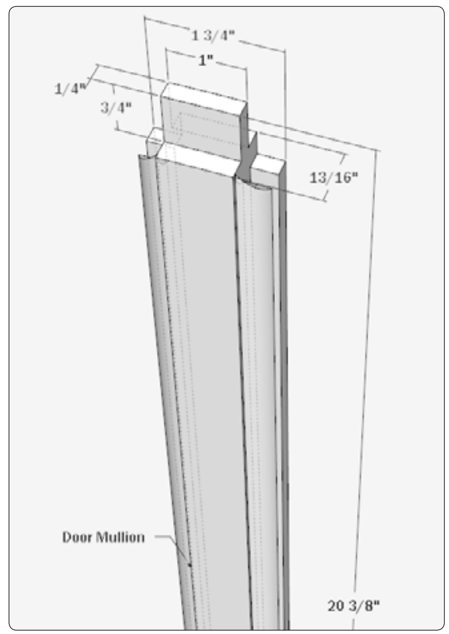


Figure 78. *The door mullion's joint details.*

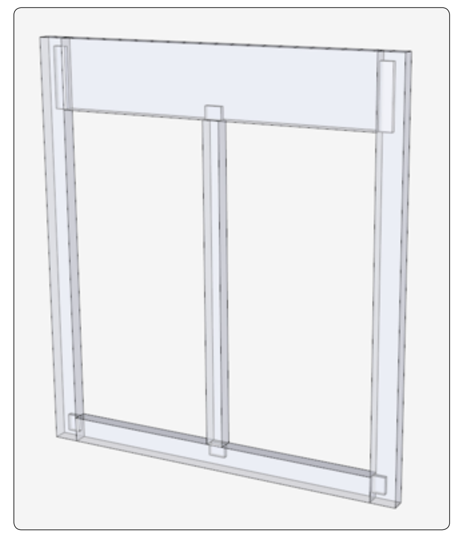


Figure 79. *The door frame components, with their joinery.*

3⅛ in., but that is from the lower edge of the rail that includes the ⅜-in.-deep beaded-grooved shape. So, to compensate, place a guideline ⅜ in. below the bottom edge of the rail, as shown in Figure 81. Draw the circle, delete part of it that extends below the edge of the rail, then use the Push/Pull Tool to push out the arch. Repeat for the other arch.

Step 26 Figure 82 shows a cross-section of the door stile with the fingernail molding and the groove for the panel. The molding and groove are the same for all the door parts and need to be added to each one.

Create a shape for the molding and groove, as shown in Figure 83. This is a flat profile with no thickness. Make the shape a component.

Orbit for a view of the upper corner of the door stile where it meets the top rail. Open the stile for editing, open the Component Dialog Box, scroll through the components in the model, and click on the molding and groove shape you just created. This generates a copy of the component, which you can drag into the model and place in the corner where the stile and rail meet, as shown in Figure 84.

By opening the stile for editing, the molding-and-groove shape is now part of the component: within the component definition, in SketchUp parlance. Explode the shape by right-clicking on it and choosing Explode from the pop-up menu. Use the Push/Pull Tool to extend the shape down the full length of the inside edge of the stile. Stop the movement at the top edge of the lower rail. See Figure 85. Repeat this procedure to add the beaded groove to both sides of the mullion.

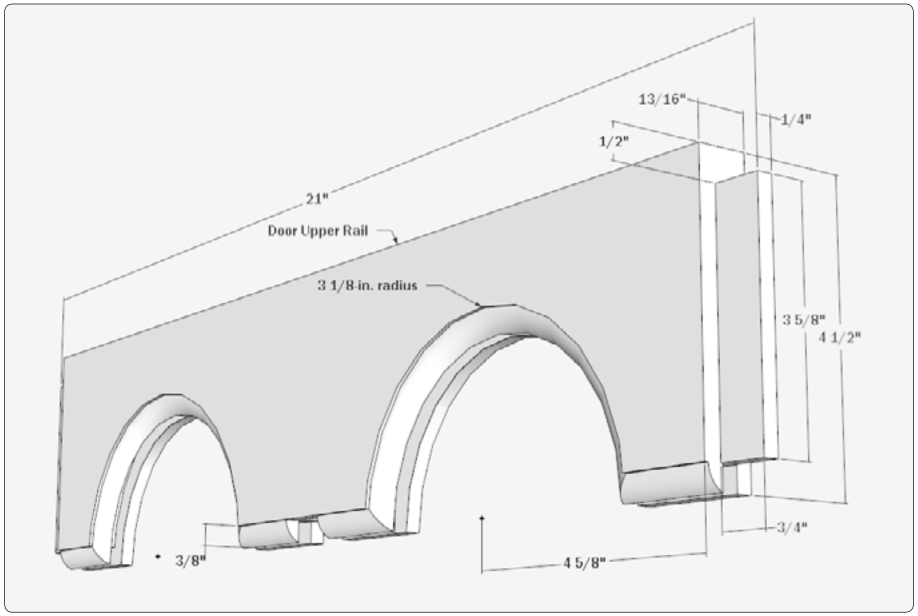


Figure 80. *Dimensions for the arched door upper rail.*

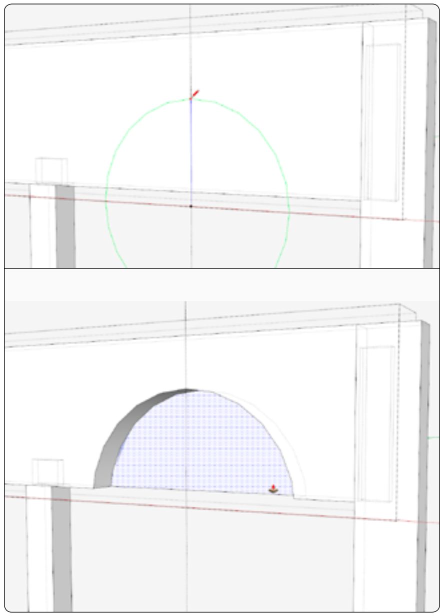


Figure 81. *Create the arched cutout in the door upper rail.*

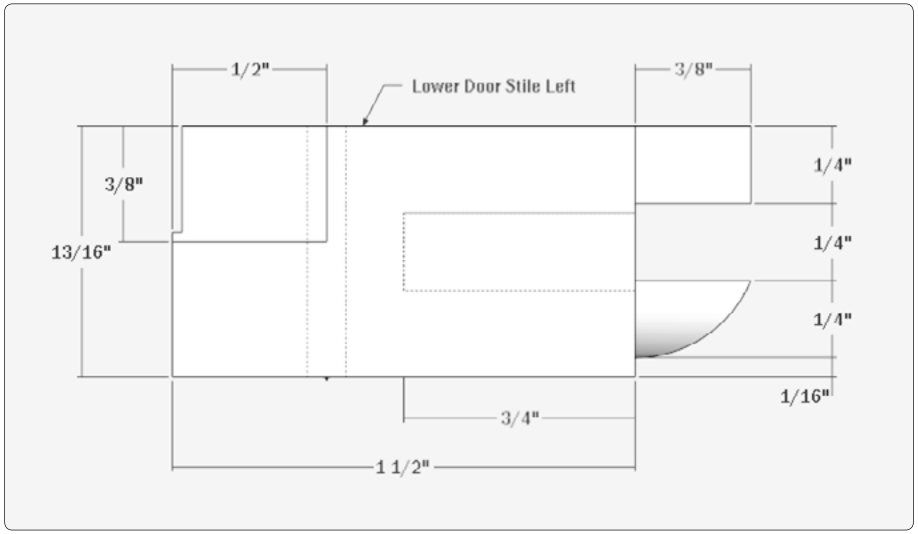


Figure 82. *A cross-section of the door stile. The dimensions at the upper left are for a rabbet that is cut only in the left-hand stile.*

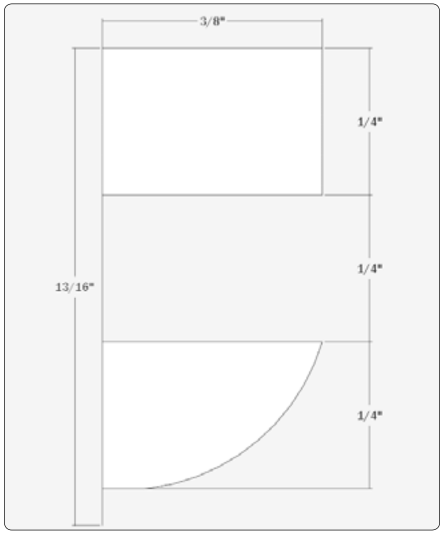


Figure 83. *The molding-and-groove shape for the inside edge of the door parts.*

The top edge of the lower rail also needs the molding and groove. But because the molding and groove on the stile cover the corner of the rail, you will need to work on a copy of the rail to place the shape. Make the copy and move it away from the door assembly. Place the molding-and-groove shape as you did before. This time, though, you will need to rotate it 90 degrees. See Figure 86. I do the rotation with the Move/Copy Tool, but you can use the Rotate Tool instead. You may find that there are extra lines on surfaces and faces that need to be cleaned up after applying the shape. See Figure 87. Delete the copy of the lower rail.

Step 27 Adding the molding and groove to the arched top rail requires a different procedure, using the Follow Me Tool. Make a copy of the top rail and move it away from the door assembly. Open the rail for editing and place the molding-and-groove component on the lower edge, as shown in Figure 88. You will need to rotate the component 90 degrees. Explode the molding-and-groove shape as you did before.

Now use the Select Tool while holding down the Shift key to select the entire Follow Me path—the lower edge of both arches and the straight line segments on either side of them. Choose the Follow Me Tool and click on the square shape in the molding-and-groove profile. Select the Follow Me path again and click on the fingernail-molding shape in the profile. Figure 89 shows the results of the Follow Me action.

Step 28 The ends of the mullions have to be trimmed for a proper fit. Now, the ends of the mullion collide with the molding and

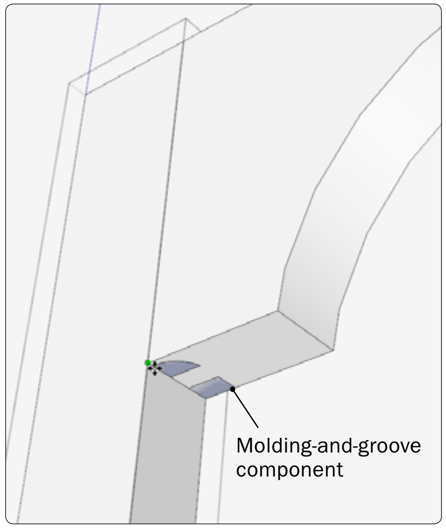


Figure 84. *Move a molding-and-groove component into position in the corner.*

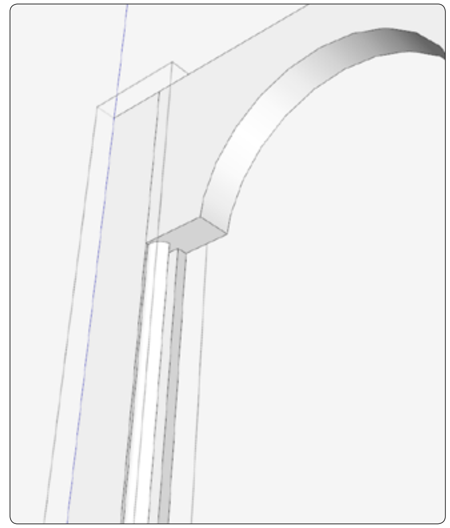


Figure 85. *Explode the molding-and-groove component and extend it.*

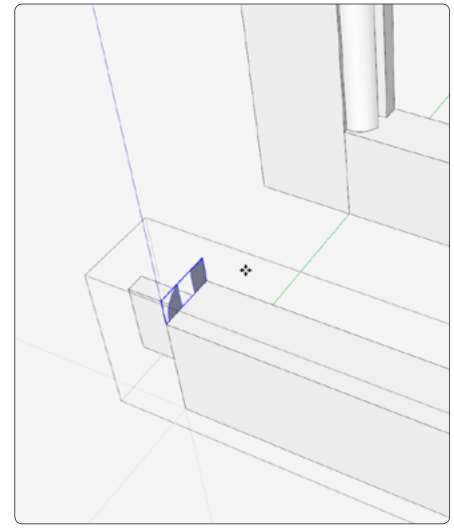


Figure 86. *Add the same shape to a copy of the lower rail.*

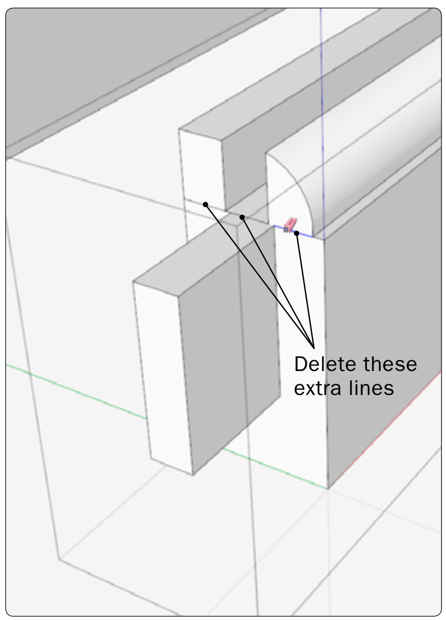


Figure 87. *Do some clean-up after adding the molding-and-groove shape.*

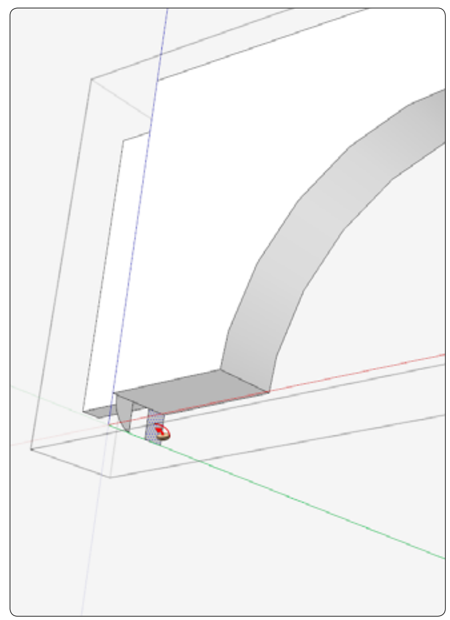


Figure 88. *Use the Follow Me Tool to add the molding and groove to the top rail.*

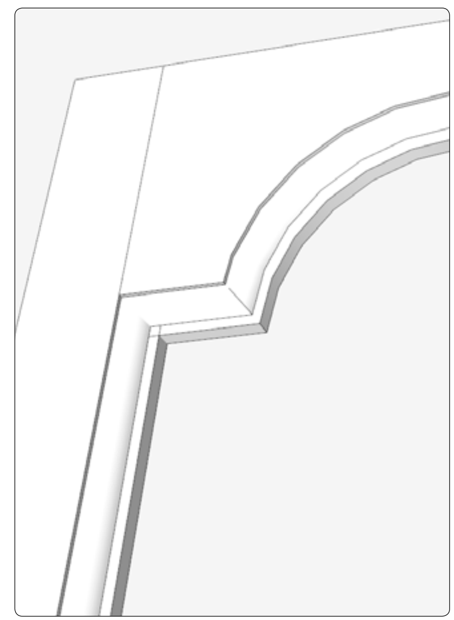


Figure 89. *The molding is there, but corners must be coped to fit properly.*

groove shape on the rails. The rails also need to be trimmed to avoid this conflict.

Orbit for a view of the back side of the door assembly. You will remove a section of molding on the rail where the flat portion of the mullion meets it. Open the lower rail for editing and trace lines over the 1-in. by ⅜-in. rectangle where the mullion intersects the rail. See Figure 90. Select the Push/Pull Tool and tap the Ctrl key (Option on Macs). Push out the rectangular shape so that it protrudes through the front of the rail. Move a copy of the rail in front of the door assembly. Triple-click on the component, right-click on the selection, and choose Intersect with Selected from the pop-up menu. See Figure 91. Delete the waste, leaving a clear 1-in.-wide gap in the beaded groove, as shown in Figure 92. Repeat to create an identical gap in the upper rail.

Step 29 Next, remove instances where the square portion of the molding-and-groove shape interferes where the door-frame components meet. Begin where the mullion meets the lower rail. Orbit for a view of the back of the door again. Open the mullion for editing and trace over the horizontal straight lines where the shapes intersect, as shown in Figure 93. Use the Push/Pull Tool to remove the small rectangles from each side of the mullion. Repeat where the mullion meets the top rail. Follow this procedure to remove interference points where the stiles and rails meet. See Figure 94.

Step 30 This step is required for inspection, clean-up, and touch-up. You have been working on the door assembly and may be somewhat blind to hidden details. Orbit to

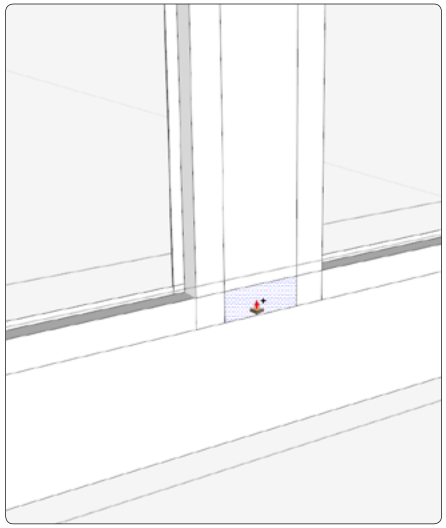


Figure 90. *Create a gap in the beaded groove on the rail for the mullion.*

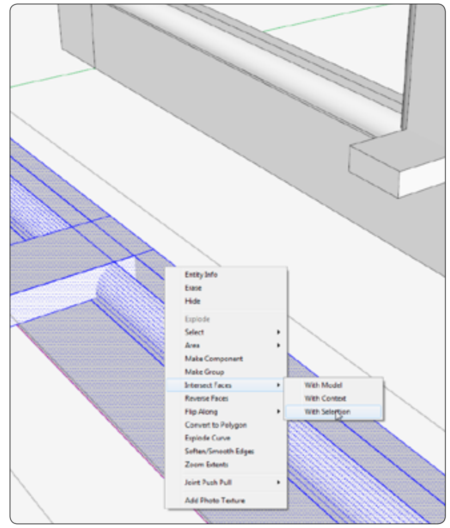


Figure 91. *Do an Intersect with Selection to create the gap in the beaded groove.*

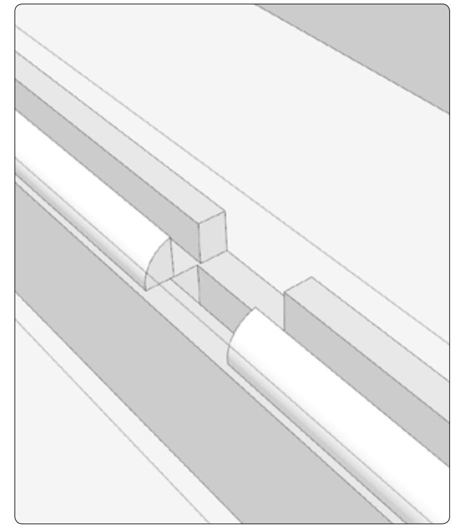


Figure 92. *Remove the waste.*

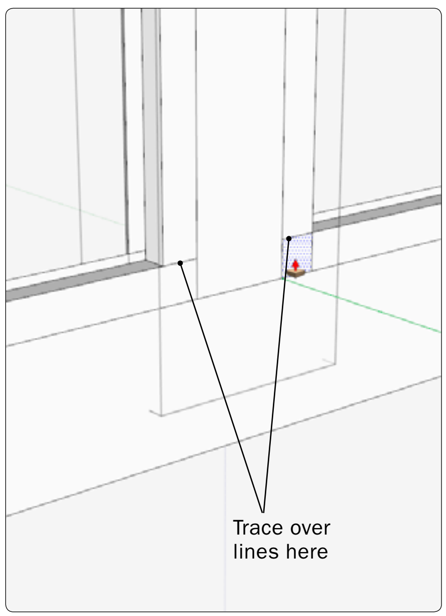


Figure 93. *Remove the interference at the rear of the mullion.*

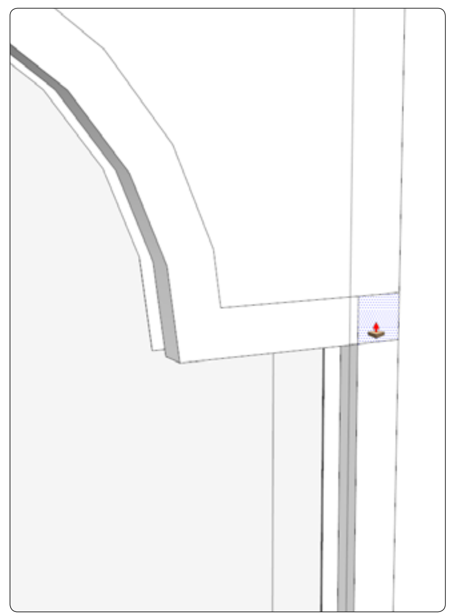


Figure 94. *Also remove the interference where the rails and stiles intersect.*

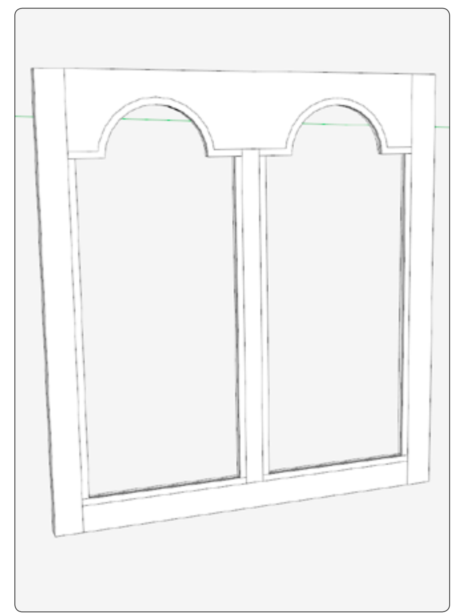


Figure 95. *The rear of the door assembly after removing all the interferences.*

a rear view of the assembly and hide the top rail. Zoom in close to the top of the mullion, as shown in Figure 96.

As you can see, the component has missing faces on the end of the fingernail molding, two extra faces, and extra lines at the base of the tenon. You can quickly fix all those faults with the Select, Eraser, and Line Tools and the Delete key. Check the other end of the mullion and the ends of the other door components, cleaning them up as needed.

With the cleanup completed, you're ready to cope the ends of the fingernail molding on the stiles and the mullion.

Step 31 The original corner cupboard used coped joints on the door frame, where the fingernail molding at one end is cut with a curved shape to fit over the mating piece. This makes a better connection than a mitered joint because it reduces the chance of a gap opening at the corner.

Making coped joints in SketchUp requires the use of the Intersect function to create the curved shapes.

Begin by making a cope cutter. Use the fingernail-molding portion of the molding-and-groove component to make a short piece of rounded-over molding strip, as shown in Figure 97. Explode the component and delete the square portion, which is not needed. Scale this up by a factor of 10 and make the cope cutter a component.

Scale up the door stile by a factor of 10 and open it for editing. In the Component Dialog Box, select the cope cutter and move it into position on the stile so that the corners of the fingernail shapes meet, as shown in Figure 98. Explode the cope cutter and triple-click on the stile to select all of the faces and edges. See Figure 99. Right-click on the selection and choose Intersect Faces with Selection from the pop-up menu.

Draw a right-to-left selection box around the end of the cope cutter, then press the delete key. This will remove all the edges and faces, except for those within the intersecting corner. Use the Eraser Tool to remove any remaining waste. See Figure 100.

In this case, the tip of the coped joint did not intersect to a point. That's because when I first drew the fingernail shape, I began with a short straight line at the tip. You may not see this, depending on how you drew the fingernail. To clean up the shape, I drew a diagonal line to finish the coped end. See Figure 101.

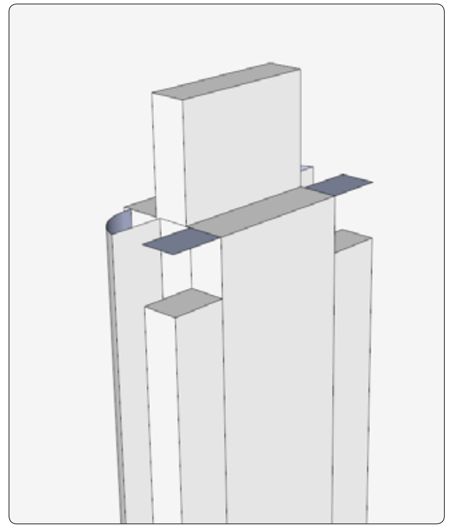


***Figure 96.** The end of the mullion before it is cleaned up.*

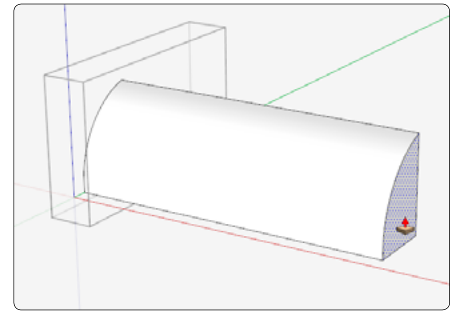


***Figure 97.** Make the cope cutter.*

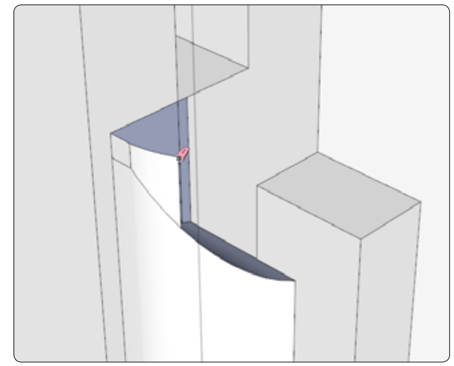


***Figure 100.** Delete waste after intersecting the faces.*

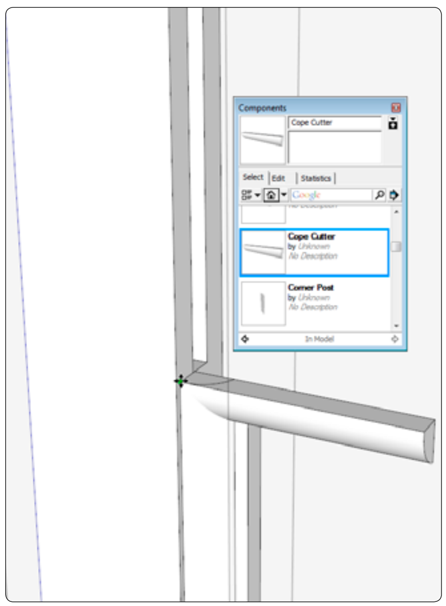


***Figure 98.** Grab a copy of the cope cutter from the Component Dialog Box.*

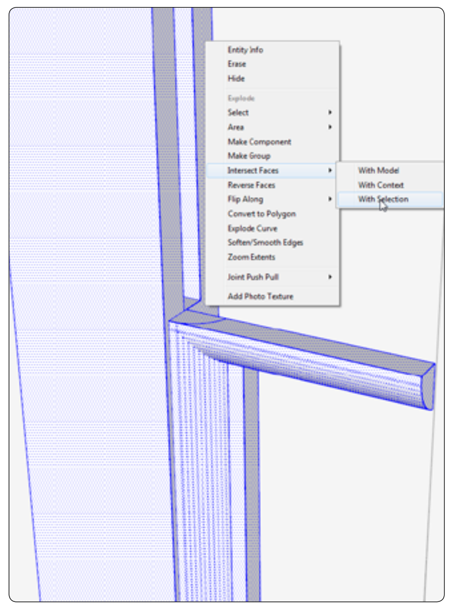


***Figure 99.** Execute an Intersect Faces with Selection command.*

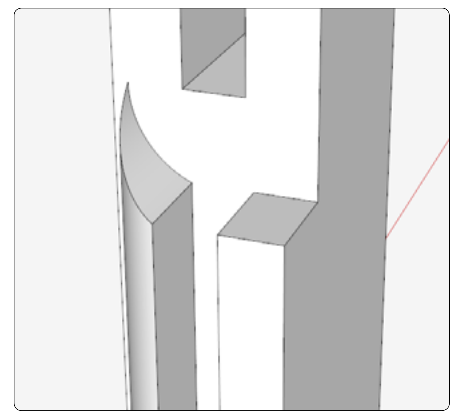


***Figure 101.** The completed coped joint.*

Step 32 Use this cope joint to make the others. Select the curved cope shape and make it a component, as shown in Figure 102. Open up the stile for editing and select this newly created component from the Component Dialog Box. Flip the copy along the blue axis and connect to the lower end of the stile, as shown in Figure 103. Explode the component and use the Eraser Tool to remove the waste.

Repeat to cope the fingernail molding on the four corners of the mullion.

Step 33 The frame is ready for the door panels. I found it hard to make the Margon dimensions work, so I've given my dimensions in Figures 104, 105, and 106.

When creating a door panel, you must position it correctly in the stile and rail grooves to allow for seasonal expansion and contraction. Figure 106 shows how the panel bevel sits in the groove. It fits snugly yet maintains a 1/16-in. air gap for expansion.

Begin by drawing a rectangle around the opening for the panel, as shown in Figure 107. Make the rectangle a component. At this point, the sides of the rectangle fall on the outer edge of the stiles and rails. Once you have made the basic shape, you will enlarge it to fit in the groove.

Complete the shape of the panel by placing a circle in the upper arch. The center of the circle falls on the midpoint of the top edge of the rectangle. See Figure 108.

The panel needs to grow by 5/16 in. around its perimeter to fit into the stile and rail grooves properly. Use the Offset Tool to create this expansion. See Figure 108. Make the panel 11/16 in. thick (Figure 109).

Use the Follow Me Tool to cut the shape

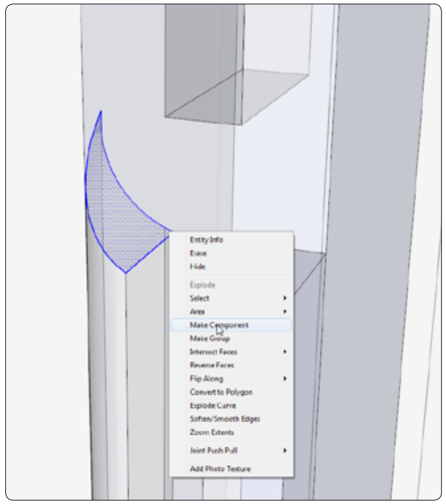


Figure 102. Select the curved cope shape and make it a component.

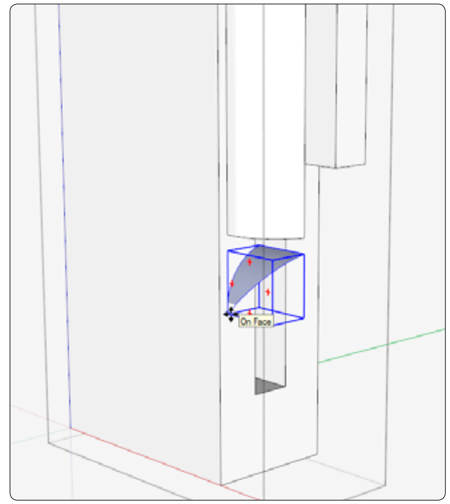


Figure 103. Bring a copy of the cope to all other locations, explode, and remove waste.

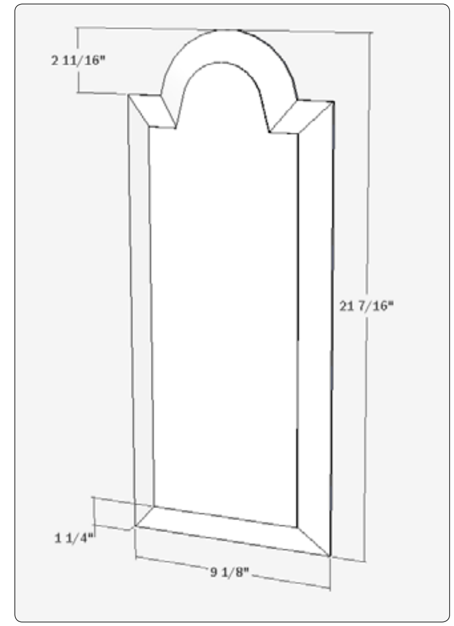


Figure 104. The dimensioned door panel.

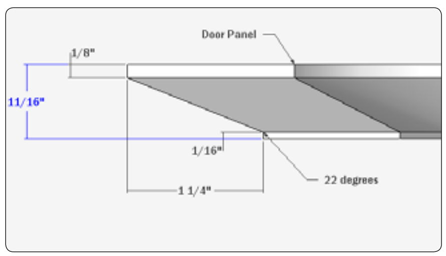


Figure 105. A top view of the door panel showing thickness and bevel angle.

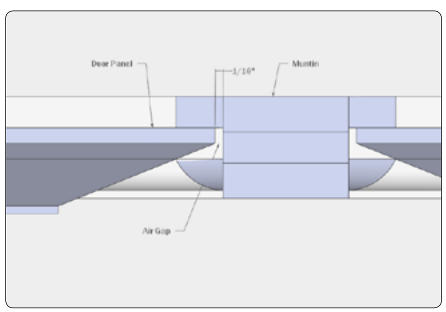


Figure 106. A cross-section showing how the door panels fit in the stile grooves.

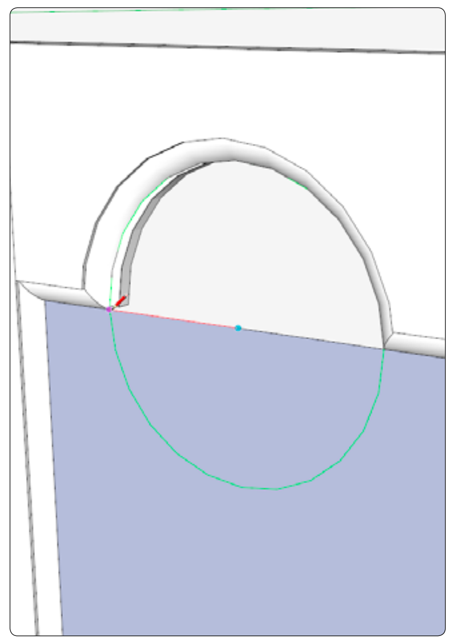


Figure 107. Draw a rectangle inside the panel opening.

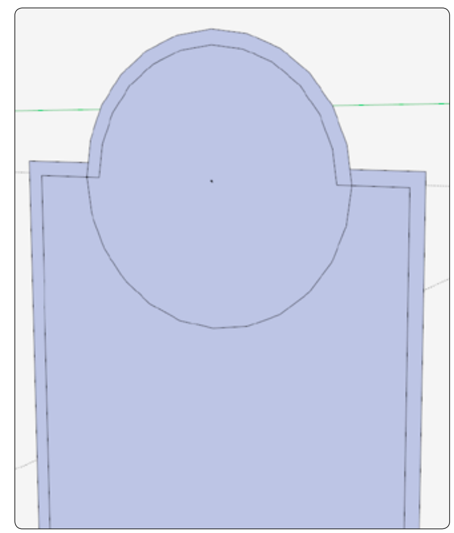


Figure 108. Increase the panel size by 5/16 in.

of the panel's beveled edge. Copy the panel component and move it away from the model. Orbit for a view of the bottom edge. Place guidelines to help you draw the shape of the bevel edge. See Figure 110; the necessary dimensions are shown in Figure 105. Select the outside edge of the panel as the path for the Follow Me Tool. Execute the Follow Me command to produce the shape shown in Figure 111.

To help position the panel within the opening, I shift the component axes to a point 5/16 in. away from both edges of a corner. This creates a grab point that will coincide with an inside corner of the door frame.

Step 34 The mortise-and-tenon joints in the stiles are held with ¼-in.-square pegs. Drill ¼-in. holes, as shown in Figure 73.

Step 35 The left stile has a ½-in. by ⅜-in. rabbet that the right one does not. Explode the left stile and make it a component again with a different name. Add the rabbet.

I chose a door lock from Ball & Ball and modeled it as shown in Figure 112. It fits on the left stile, as shown in Figure 113. To do that, I filled in part of the rabbet and gave the platform for the lock a decorative ogee shape. Next, I made a matching cutout in the lip of the carcase stile, as shown in Figure 114. These details depend on the specific hardware you choose for the project.

Step 36 Margon shows three H-hinges on the original cupboard. I used Ball & Ball hinges, as shown in Figure 115.

This completes the construction of the lower cabinet.

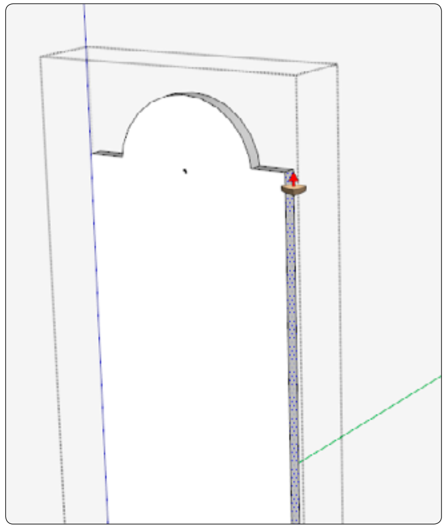


Figure 109. *Make the panel 11/16 in. thick.*

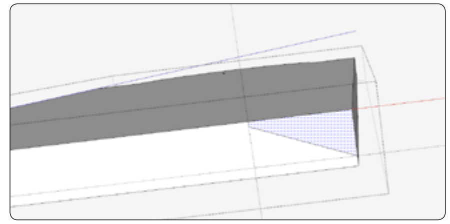


Figure 110. *Draw the shape of the beveled edge.*

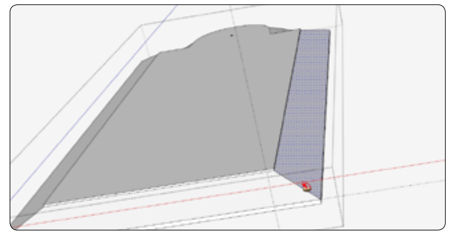


Figure 111. *Create the bevel with the Follow Me Tool.*

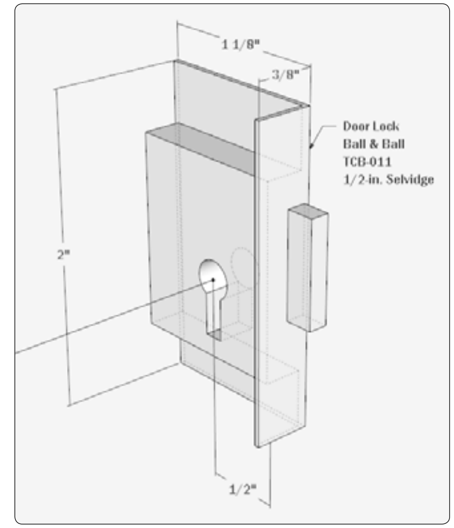


Figure 112. *The door lock.*

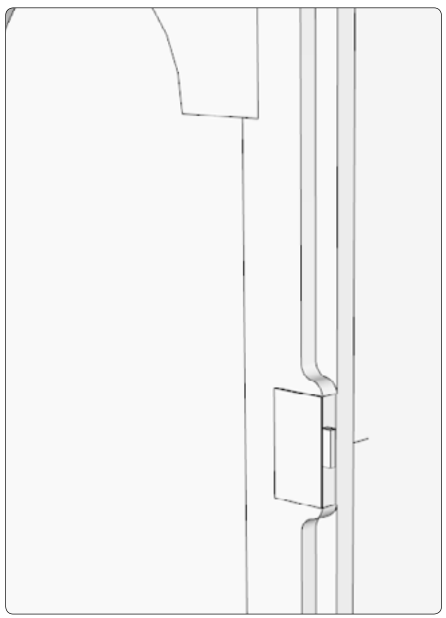


Figure 113. *The door lock installed on the back of the left stile.*

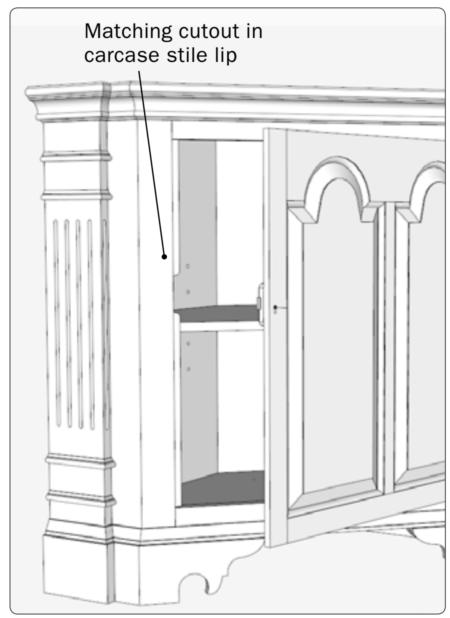


Figure 114. *The carcase door stile requires a cutout to accommodate the lock.*

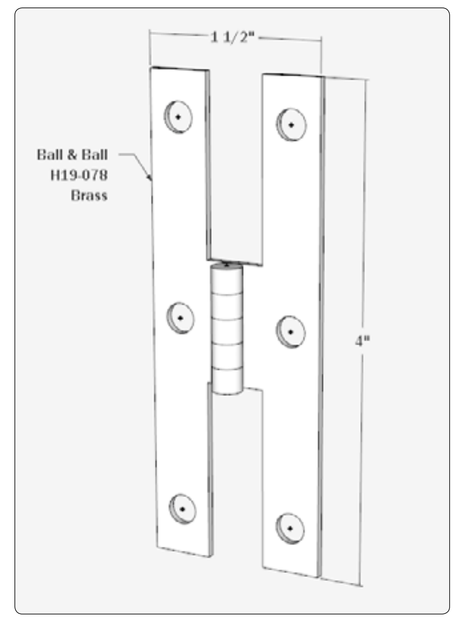


Figure 115. *The model of the door hinges.*

Status Report

The lower-cabinet section is complete, and we've used just about every tool in the SketchUp repertoire. In the shop, I would expect some difficulty in creating the splined-miter joints in the carcase, the flutes on the pilasters, and the arched door. These same areas were demanding constructions in SketchUp.

The good news is that the upper cabinet will be much easier to create because you can use components you have already built for the lower cabinet. That's one area where SketchUp modeling outshines real woodworking.

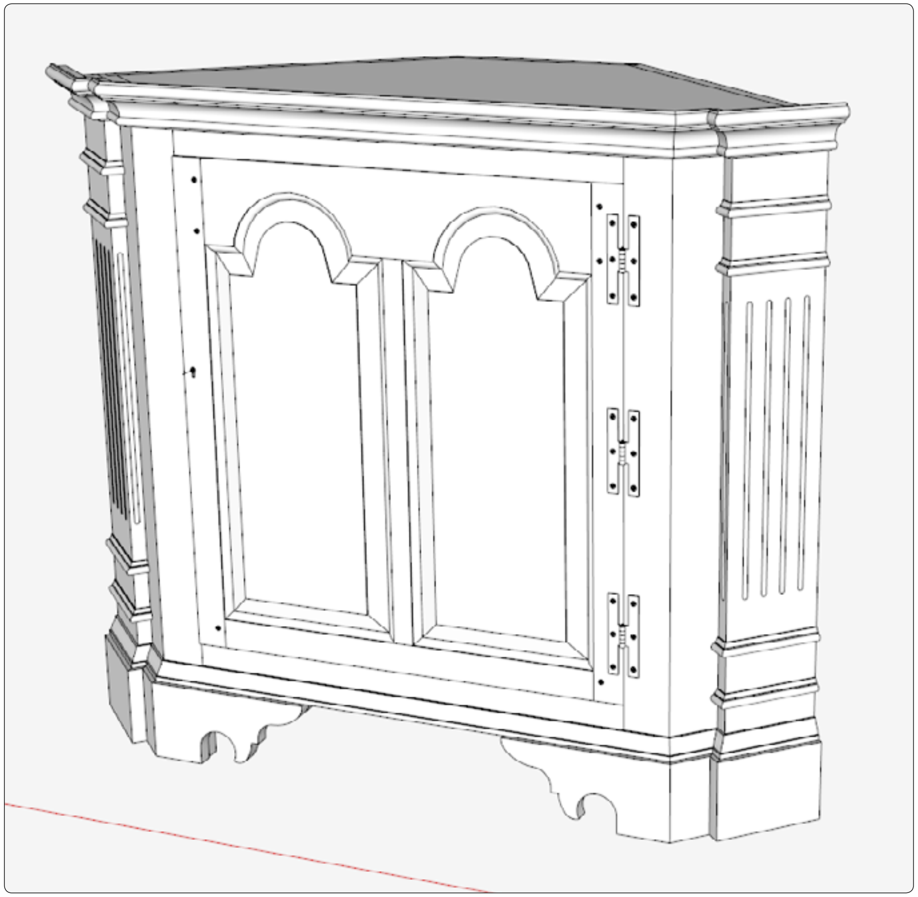


Figure 116. *The completed lower cabinet, with all its hardware in place.*

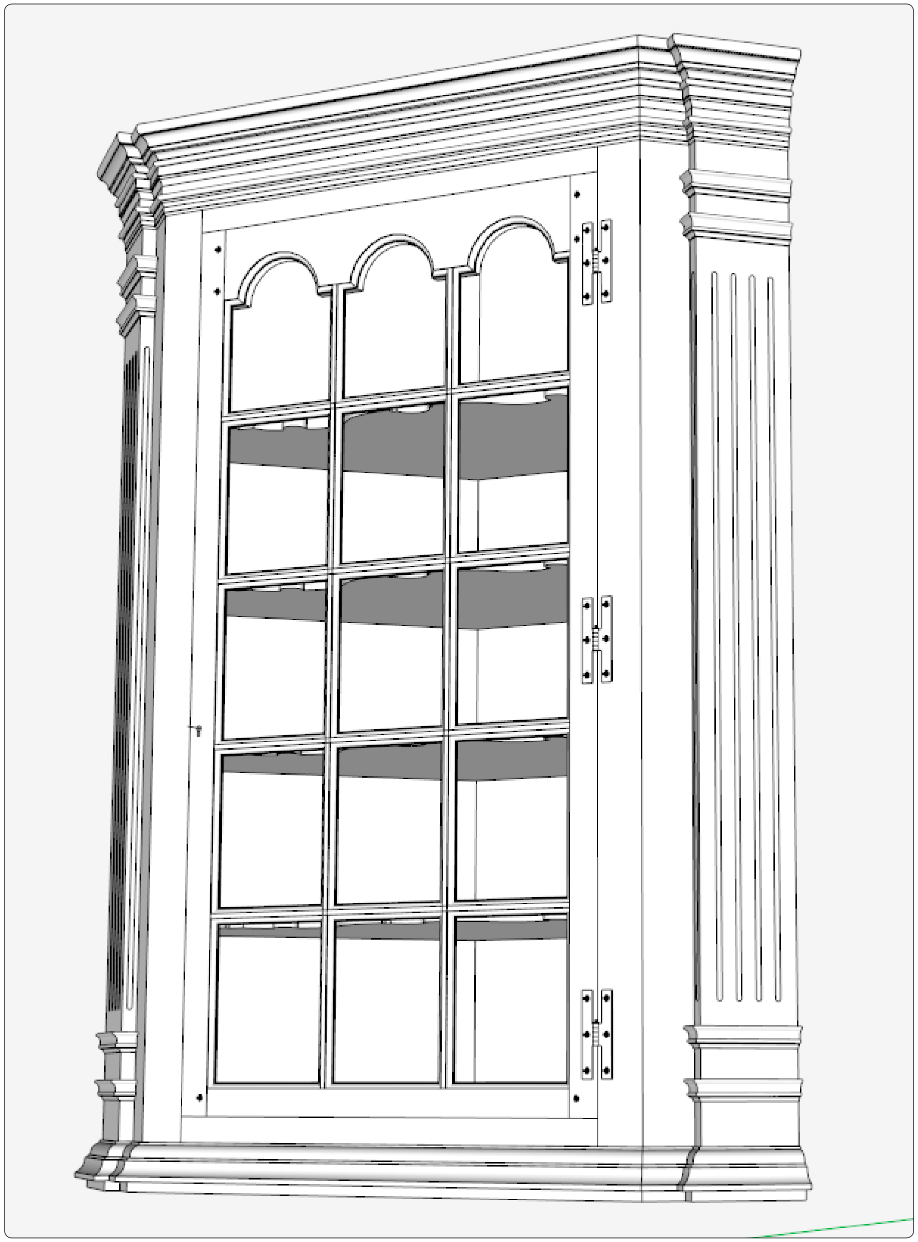


Figure 117. *The upper-cabinet assembly.*

Construct the upper carcase

We can save time building the upper carcase by using the components already developed for the lower cabinet. For the most part, the existing components need to be stretched in length to the full height of the upper cabinet. Scaling would also lengthen the components, but in the wrong way. Scaling enlarges or shrinks everything in a component proportionately, so that joinery details are changed to odd or even unusable sizes. Stretching simply changes one dimension, without altering the existing joinery or the thickness and widths of the boards.

Step 37 Make a copy of the entire lower carcase assembly and move it to the right along the red axis. Delete the facing at the base, the shoe molding, the cornice molding, the bottom, and the top.

Next, change the names of all the remaining components in the copy. If you don't, any change you make to the copy will also be reflected in the original. For example, change the name of the corner post to something like upper corner post. Inserting the word "upper" is generally all you need to do to change the name.

Right-click on each component and choose Explode from the pop-up menu. Right-click on the selection and choose Make Component from the menu. Enter the new name and click on Create.

Step 38 The bottom component in the upper cabinet is larger than the bottom in the lower carcase. Instead of being hidden inside, the upper bottom's edges are exposed; it serves as a platform on which the rest of the parts sit. See Figure 119.

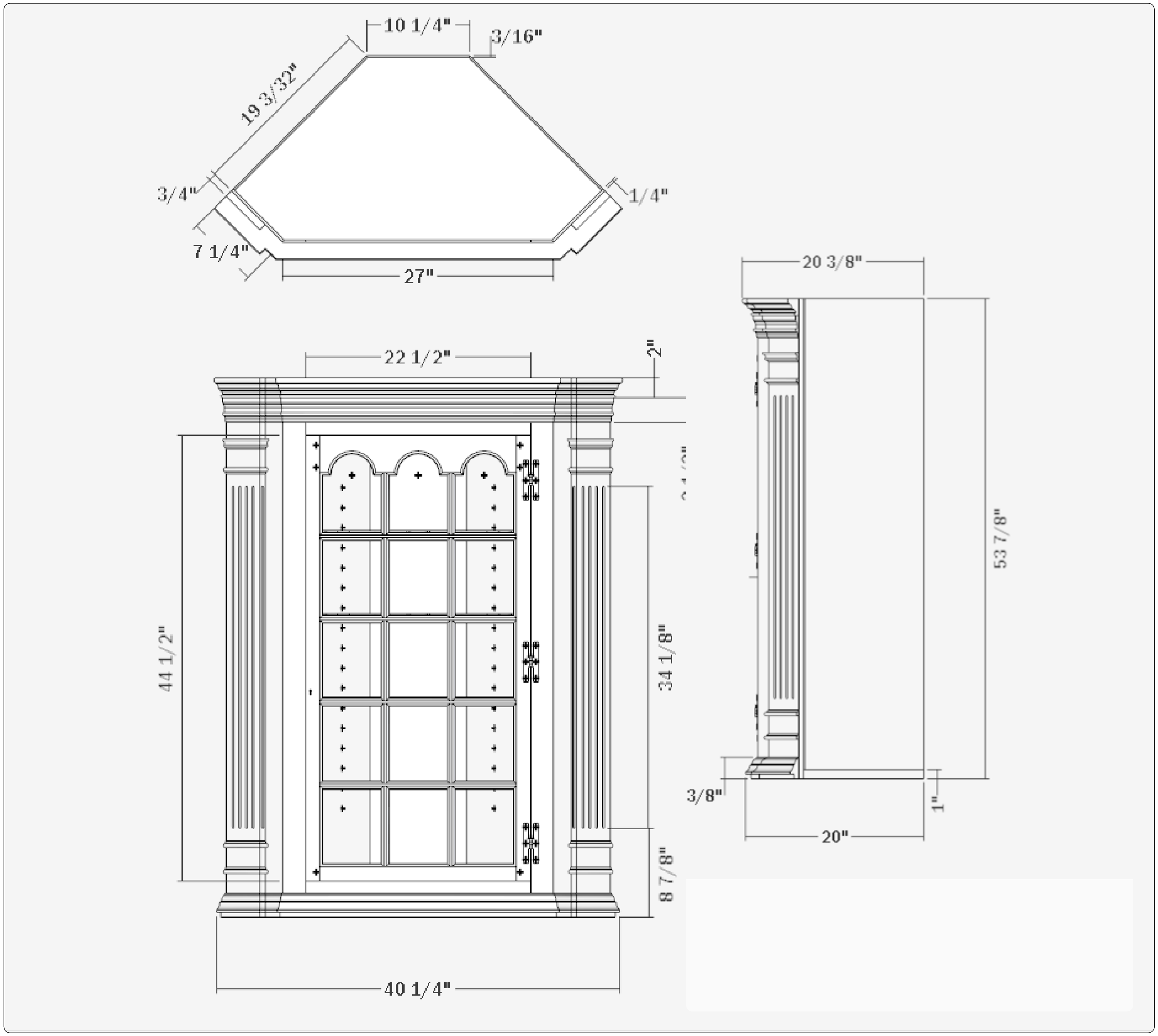


Figure 118. *Front, side, and plan views of the upper cabinet.*

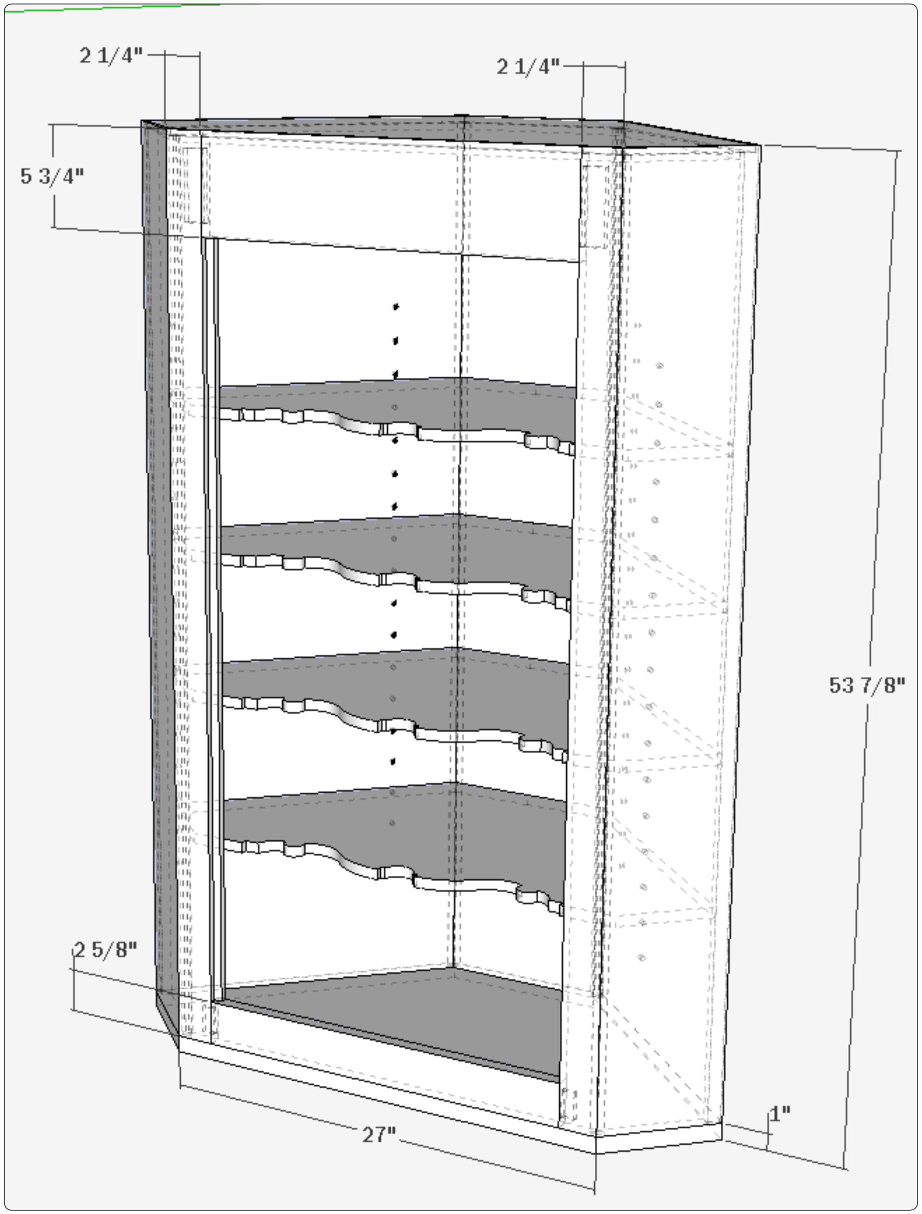


Figure 119. *The assembled upper carcase.*

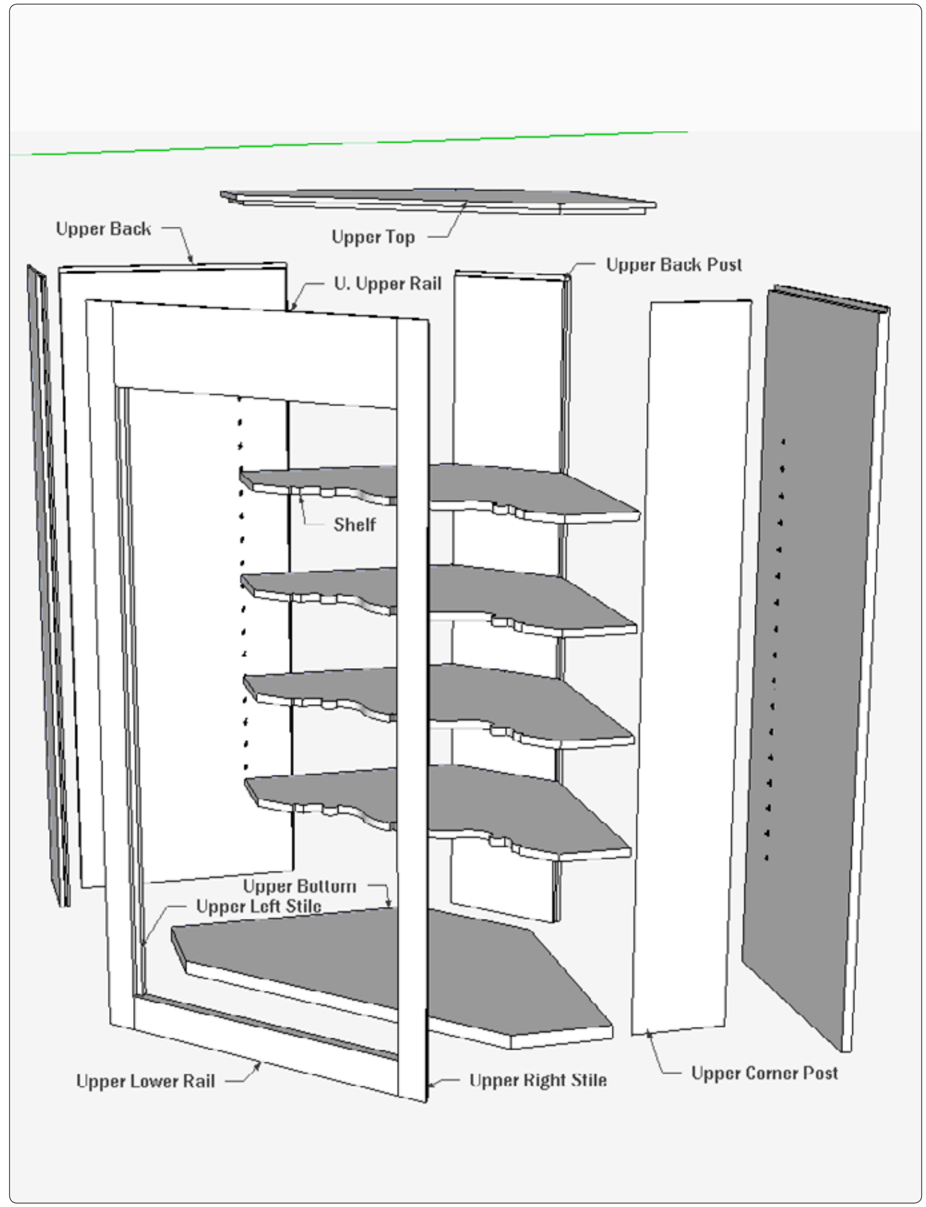


Figure 120. *An exploded view of the upper carcase.*

Use the Line Tool to trace over the outside bottom edge of the carcase, creating the perimeter of the new bottom component. Double-click on the face and make it a component. See Figure 121. Now give it a thickness of 1 in. Pull the thickness down along the blue axis, so the bottom component is below the rest of the carcase.

Step 39 Place a guideline to show you the full height of the upper carcase. Click the Tape Measure Tool on the front bottom edge of the carcase bottom. Begin moving the cursor up along blue axis, type 53⅞, and press the Enter key. This places a guideline precisely.

To stretch the carcase stile, open it for editing, then draw a left-to-right selection box around the upper end of the stile, as shown in Figure 122. Be sure to draw the selection box large enough to include all the mortises and the top face and edges of the rabbet. You can switch to X-Ray style to ensure that your selection is correct. Try again if you think you have missed an element.

Choose the Move/Copy Tool and click it on the top edge of the stile. Move the cursor up along the blue axis (it helps to tap the Down or Up Arrow Key to constrain the movement) and click when you reach the guideline. See Figure 123. Do the same stretching operation on the back post, back, and corner post. Figure 124 shows the back post being stretched.

Step 40 Move the two front rails to the ends of the stiles and change their widths. See Figure 125. The lower rail is 2⅝ in. wide; the upper rail, 5¾ in. Modify the widths by placing a guideline and using the Select and

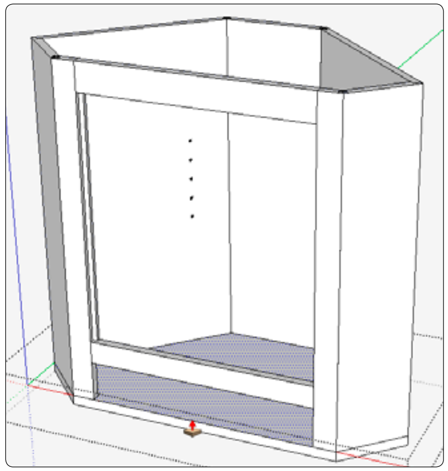


Figure 121. *Trace the outline of the carcase to shape the bottom component.*

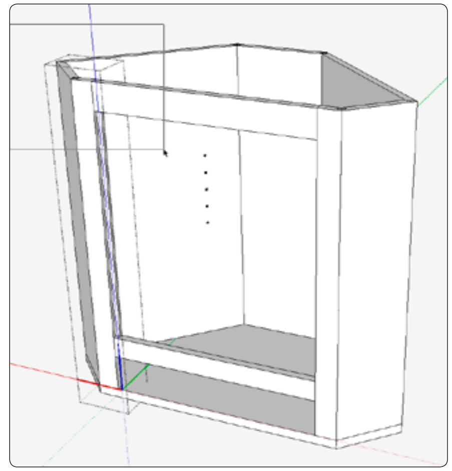


Figure 122. *Select the top of the stile, including all of the mortises and the rabbet.*

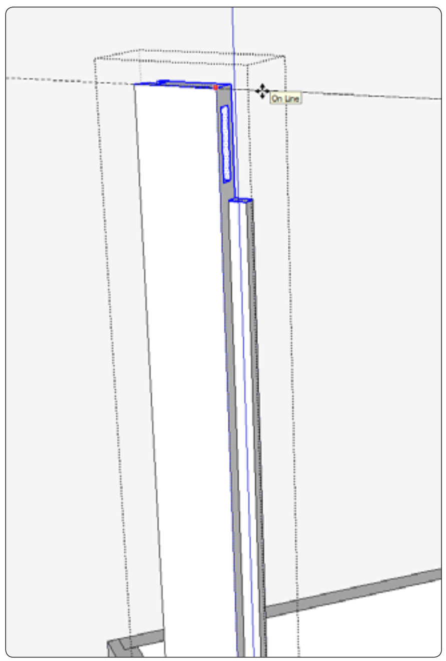


Figure 123. *Move (or stretch) the stile until it is the full height of the upper cabinet.*

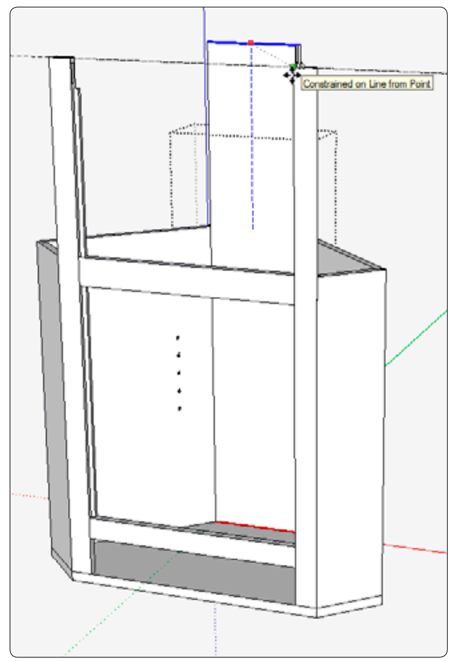


Figure 124. *Pull up the back post to the full height.*

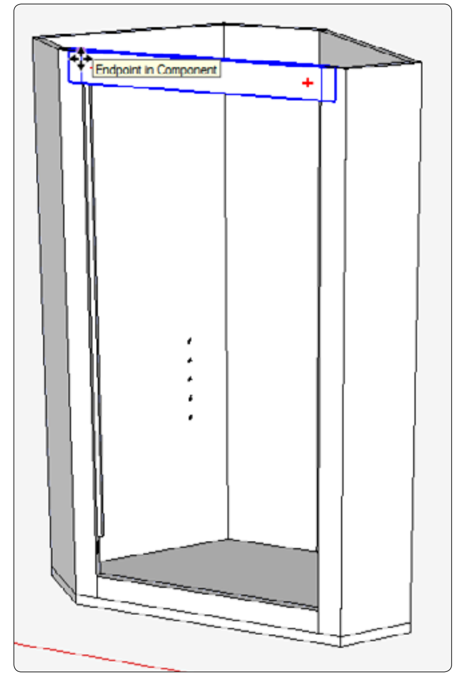


Figure 125. *Move the lower and upper rails to the ends of the stiles.*

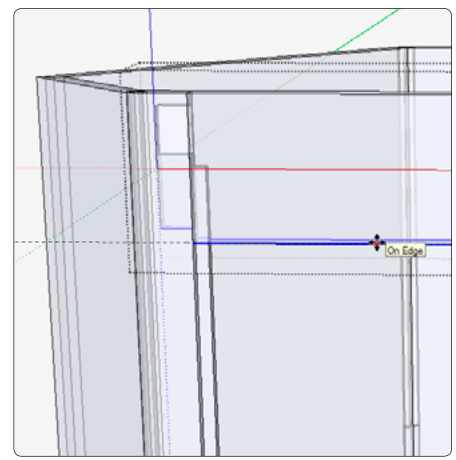


Figure 126. *Increase the width of the upper rail and enlarge the mortise in the stile.*

Move/Copy Tools as you did to stretch the other components. Figure 126 shows the upper rail being modified. It is in X-Ray view to make sure that the bottom edges of the tenon at both ends have been selected. That will ensure that the tenon is elongated as the rail is widened. The mortises in the stiles must be elongated to match. Open the stile for editing and use the tenon to gauge the size of the mortise. Repeat for the mortise at the lower end of the stiles.

Step 41 The top edge of the carcase has a ⅜-in. by 9/16-in. rabbet around its inside perimeter. The top component has a matching rabbet and sits flush with the top of the carcase. Cut the rabbet in each of the carcase components by placing a guideline, tracing over it with the Line Tool, and pushing the rabbet to depth with the Push/Pull Tool. See Figure 127.

Step 42 Create the ¾-in.-thick top component by tracing around the carcase with the Line Tool. Follow the top edge of the rabbet, not the outside edge of the carcase. Make the face a component and give it a thickness of ⅜ in., as shown in Figure 128. Copy the top and move it up above the carcase. Orbit for a view of the bottom face. Use the Offset Tool to make a 9/16-in. offset line around the border. Pull out the center face another ⅜ in. This gives the top its overall thickness ¾ in. See Figure 129.

Step 43 Creating the rabbet in the top edge left the top of the mortise-and-tenon joint too close to the bottom of the rabbet. So, as shown in Figure 130, adjust the size of the mortise and tenon to leave a ½-in. shoulder

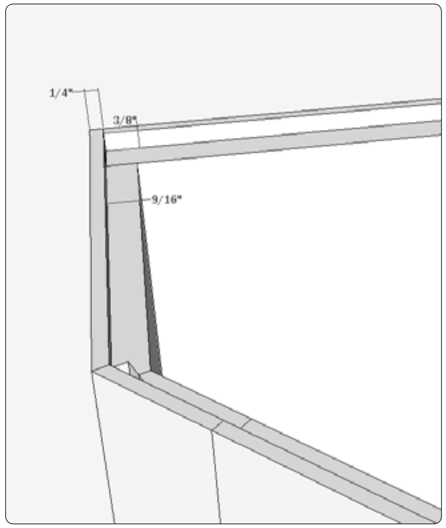


Figure 127. *Create the rabbet in the top edge of the carcase components.*

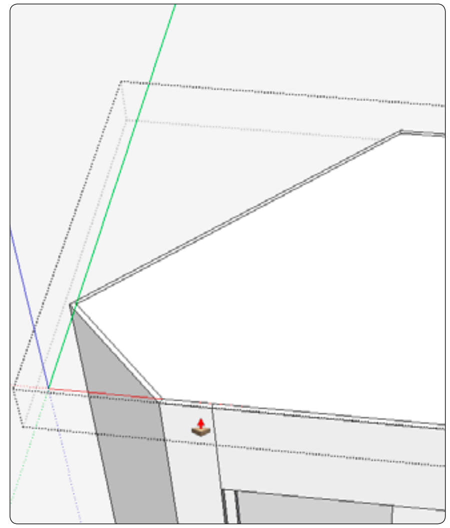


Figure 128. *Make the top component by tracing around the edge of the rabbet.*

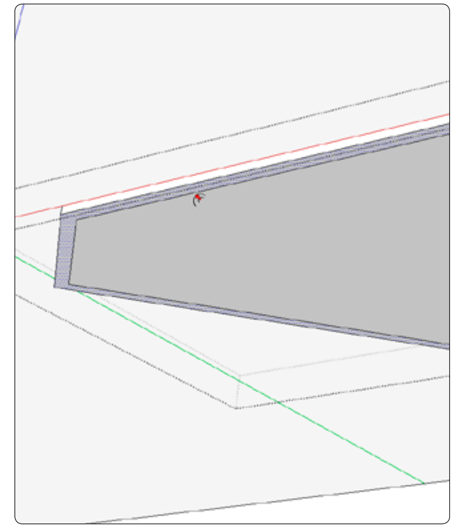


Figure 129. *Create the rabbet joint by using the Offset Tool and the Push/Pull Tool.*

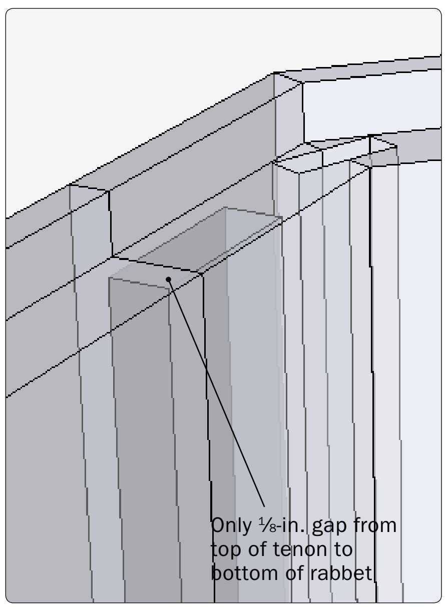


Figure 130. *Lower the top of the mortise-and-tenon joint.*

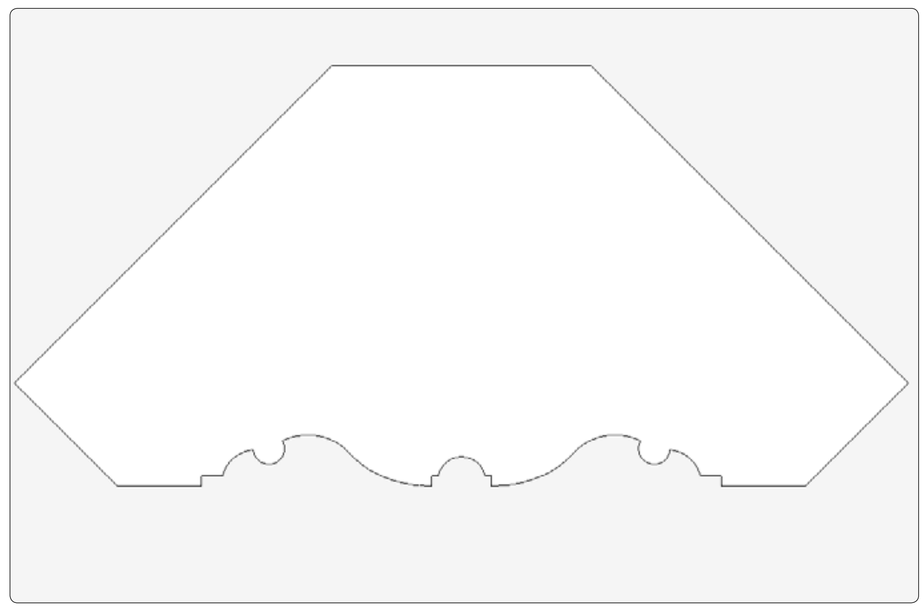


Figure 131. *Scan this shape, import it into SketchUp, trace over it, and use it to push out the waste in the front edge of the shelf.*

at the top. Open the rail for editing, change the size of the tenon, then use the tenon to help shape the mortise.

Step 44 Use the shelf component from the lower cabinet to make the upper shelves. They are the same overall size, but the upper shelf has a beautiful scrolled front edge. It probably has a purpose, allowing taller items to be stored in the cabinet.

Scan the shape in Figure 131, import it into SketchUp, and trace over the scrolled shape with the Line and Arc Tools. Place the shape on the shelf and push out the waste. Or, if you prefer, you can create your own scroll shape directly on the shelf.

Step 45 The shelf support holes in the upper carcase are currently the ones inherited from the lower carcase. You will need to add a number of holes to accommodate the four shelves in the upper cabinet. Based on dimensions shown in Figure 118, the topmost shelf is about 38 in. from the bottom of the carcase. So the spread of the shelf support holes should extend above that height.

Make a guideline at 38 in. from the bottom face. Open the upper back component for editing, and draw a left-to-right selection box around the five existing support holes. Choose the Move/Copy Tool and tap the Ctrl key (Option on Macs). Move the copied set of holes up the blue axis, type 10, and press the Enter key. Copy one more set of five holes, which spreads them above the guideline. See Figure 132. Place another two holes below the lowest one. Repeat to add suport holes on the corner post.

This completes the construction of the basic upper carcase structure.

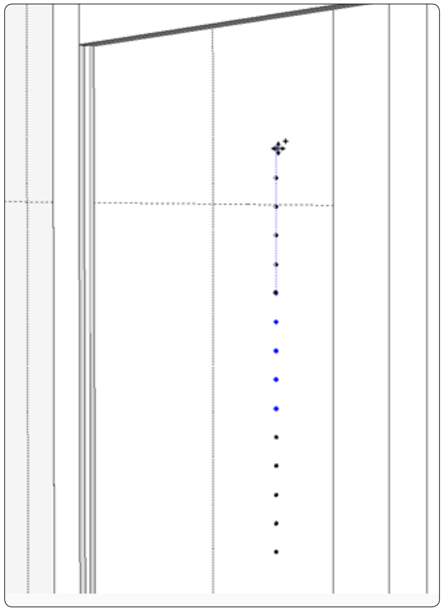


Figure 132. *Copy two sets of five support holes to accommodate all shelves.*

Status Report

The basic upper carcase structure is now complete, as shown in Figure 133. This would likely be a milestone for the upper cabinet in the shop as well.

In horizontal cross-section, the upper and lower cabinets are identical in shape and size. However, there are differences in the top and bottom components, the shelves, and the front frame parts and joinery.

In the next sections, you will apply the molding embellishments, elongate the fluted pilasters, and create the glazed door.

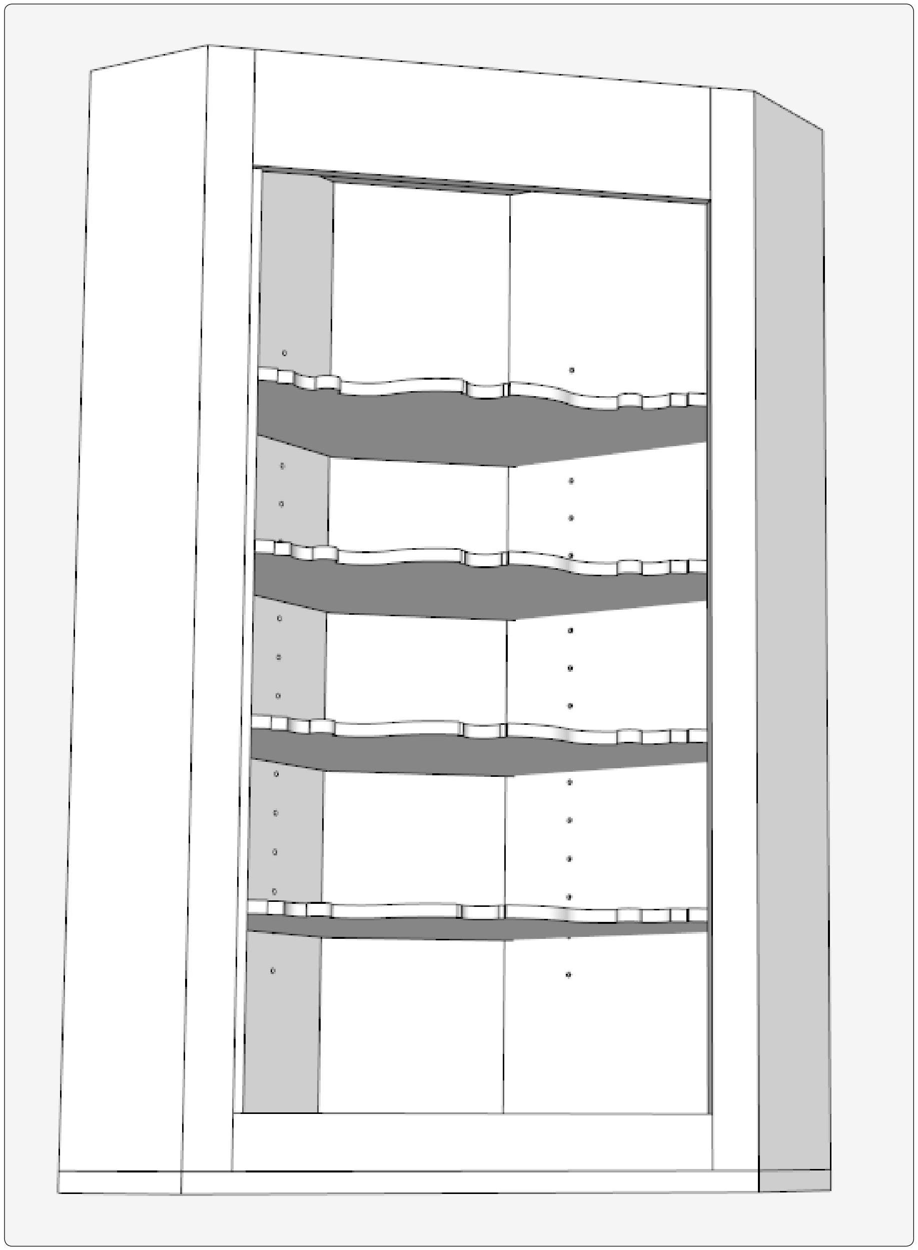


Figure 133. *The completed upper carcase structure.*

Lengthen the fluted pilasters

The pilasters on the upper cabinet are identical to those on the lower cabinet except for their height and the topmost molding strip. You can draw them from scratch, using the same procedures you followed for the lower cabinet. However, it's easier and faster to create them by stretching the lower pilaster. The easiest way I've found is to start by using the lower pilaster component and modifying its overall length, the length of the flutes, and the position of three molding strips. The top molding strip is unique.

Step 46 Begin by opening a copy of the lower cabinet's pilaster. If you haven't done so already, rename the component.

Place a guideline 53⅞ in. up from the bottom of the pilaster, as shown in Figure 135. Use the Push/Pull Tool to lengthen the pilaster to that guideline. Place a guideline 8 ⅞ in. from the bottom edge of the pilaster, the point where the bottom of the flutes fall. Click on the View tab in the menu bar and choose Hidden Geometry. Many dotted lines immediately appear in the flutes. See Figure 136. These lines define the boundaries of the facets that SketchUp uses to produce a face.

Step 47 Draw a left-to-right selection box around the bottom of the fluted section. This highlights the hidden-geometry lines at the bottom of the flutes, as you can see in Figure 136. Choose the Move/Copy Tool, click on the bottom edge of a flute, and pull down along the blue axis to the guideline; click the mouse to end the move.

Step 48 Draw a guideline 34⅛ in. above the bottom of the flutes to mark the location of

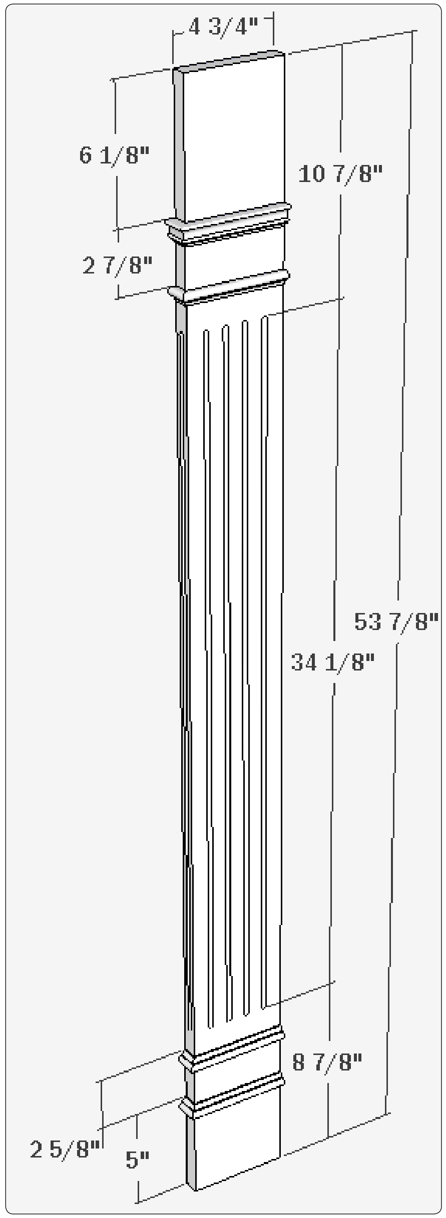


Figure 134. *The dimensions for the lower pilaster.*

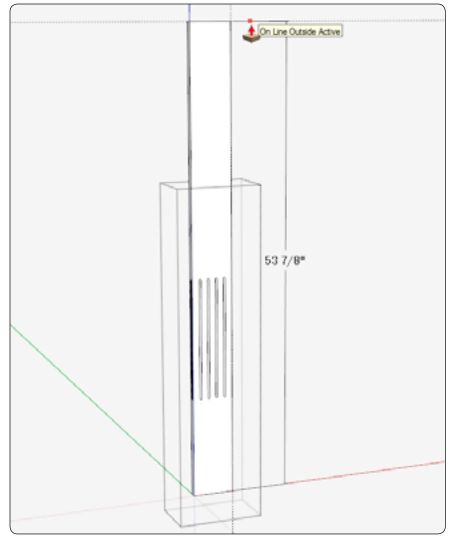


Figure 135. *Place guidelines to show the height of the flutes and the overall height.*

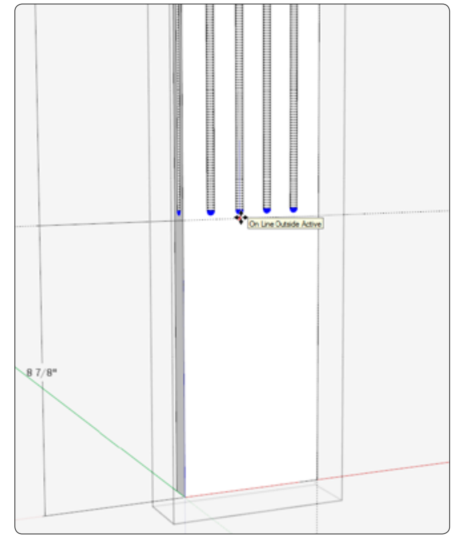


Figure 136. *Turn on hidden geometry and select the bottom of the fluted section.*

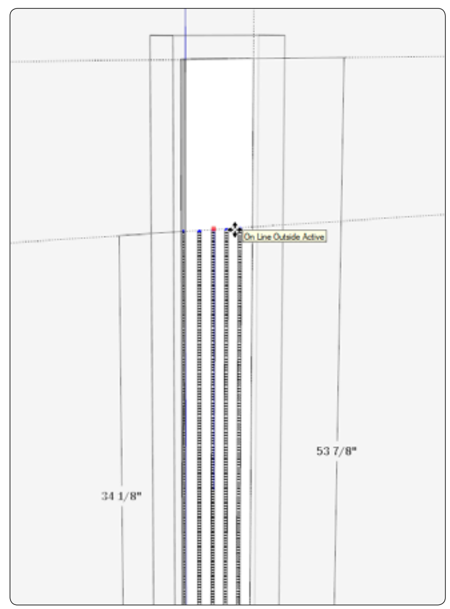


Figure 137. *Use the Move/Copy Tool to lengthen the fluted section to the guideline.*

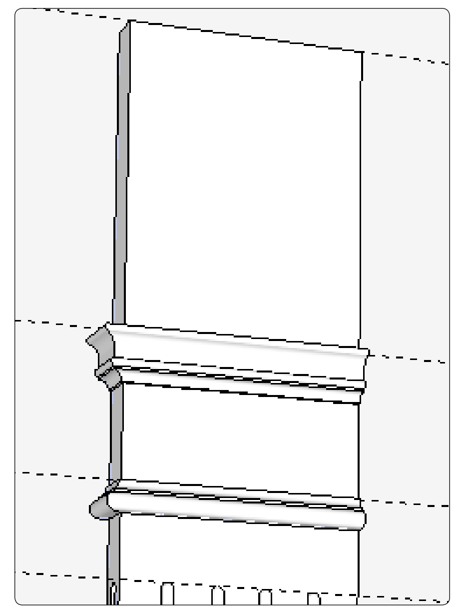


Figure 138. *Reposition the moldings and add the unique top molding strip.*

the top of the flutes. Be sure hidden geometry is still turned on. Draw a left-to-right selection box around the top of the flutes and use the Move/Copy Tool to lengthen the flutes up to the guideline. See Figure 137. Reposition the molding strips, following the dimensions in Figure 134. The topmost molding strip is unique. Copy its shape from Figure 43 and create it with the Follow Me Tool.

Create the base and crown moldings

Step 49 The crown molding consists of two components, as shown in Figure 139, which is the result of tracing over the scanned image with the Line and Arc Tools. Make two components: the upper crown molding (high) and upper crown molding (low). Make these moldings exactly as you did the crown molding for the lower cabinet. Create the profile shape and position it on the back edge of the upper pilaster, create a path, and execute a Follow Me extrusion. Do this once for each component. See Figure 141.

Step 50 Figure 140 shows the upper base molding profile shape. Create this shape and position it on the carcase bottom so that the bottom edge of the molding is flush with the bottom edge of the carcase. See Figure 142. Draw a path and execute another Follow Me extrusion.

Construct the glazed door

The glazed door has rails and muntins mortised into the stiles. The vertical muntins are mortised into the rails. All of those pieces have a fingernail molding on their inside edges. These are coped to fit at the corners and where the muntins connect to the

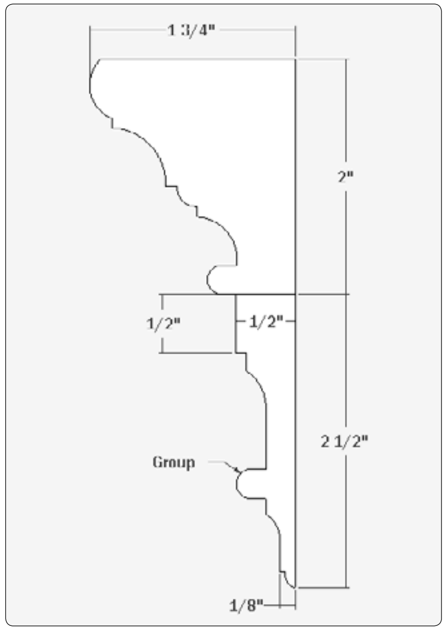


Figure 139. *The two profiles that form the upper crown molding.*

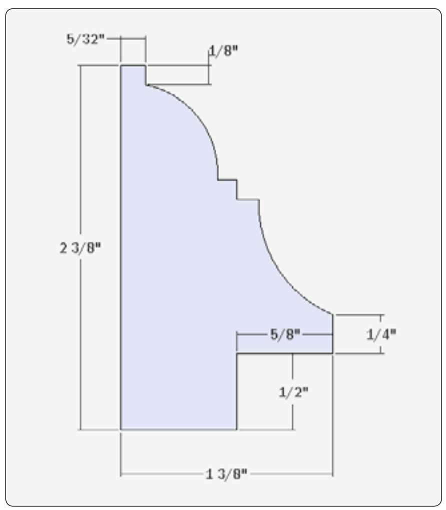


Figure 140. *The profile of the upper base molding.*

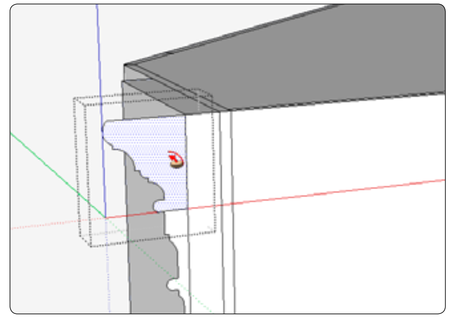


Figure 141. *Use the Follow Me Tool to extrude the upper crown molding.*

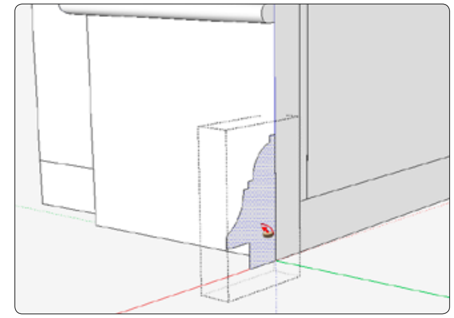


Figure 142. *Use the Follow Me tool to extrude the upper base molding.*

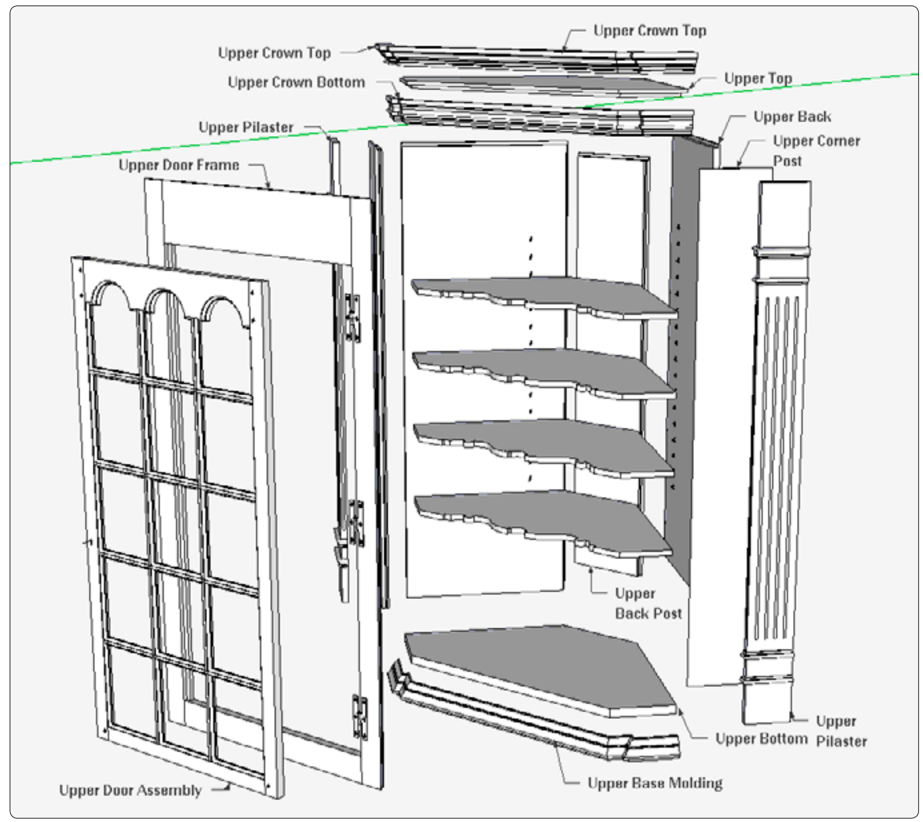
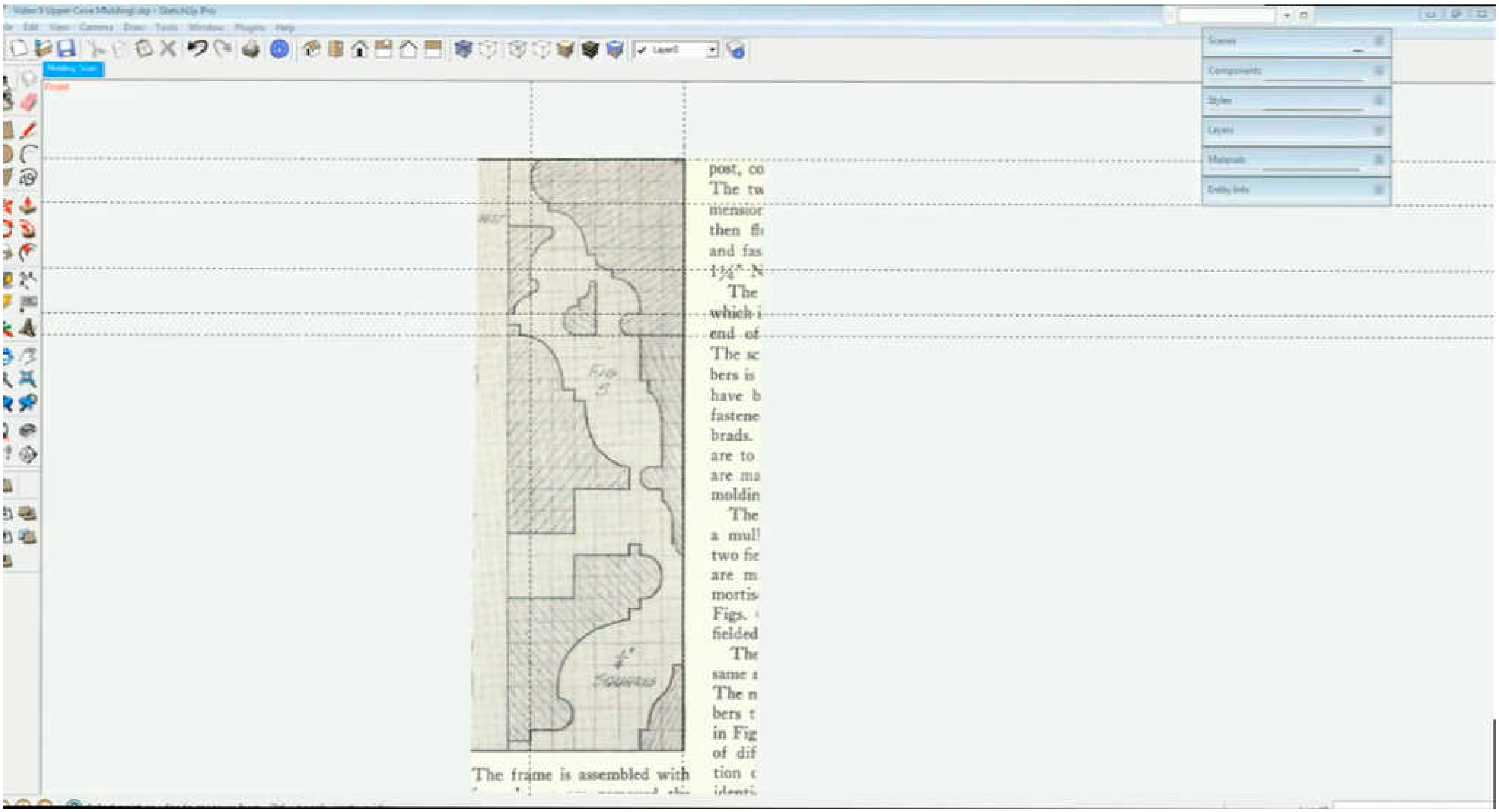


Figure 143. *An exploded view of the upper cabinet.*

Video Tutorial: Extruding the Crown Molding

Cabinets are often adorned with crown or cove molding at the top. To create those elements in SketchUp, you must first replicate the profile shape. In this case, Margon's original plan for the corner cupboard includes a small sketch that you can copy in SketchUp using the Arc and Line tools. After producing the profile shape, you use the Follow Me Tool to extrude the shape along a path that follows the upper edge of the cabinet. A crown or cove molding usually consists of a single shape to extrude. For this cabinet, however, the crown molding is quite large and built up from two separate extrusions.



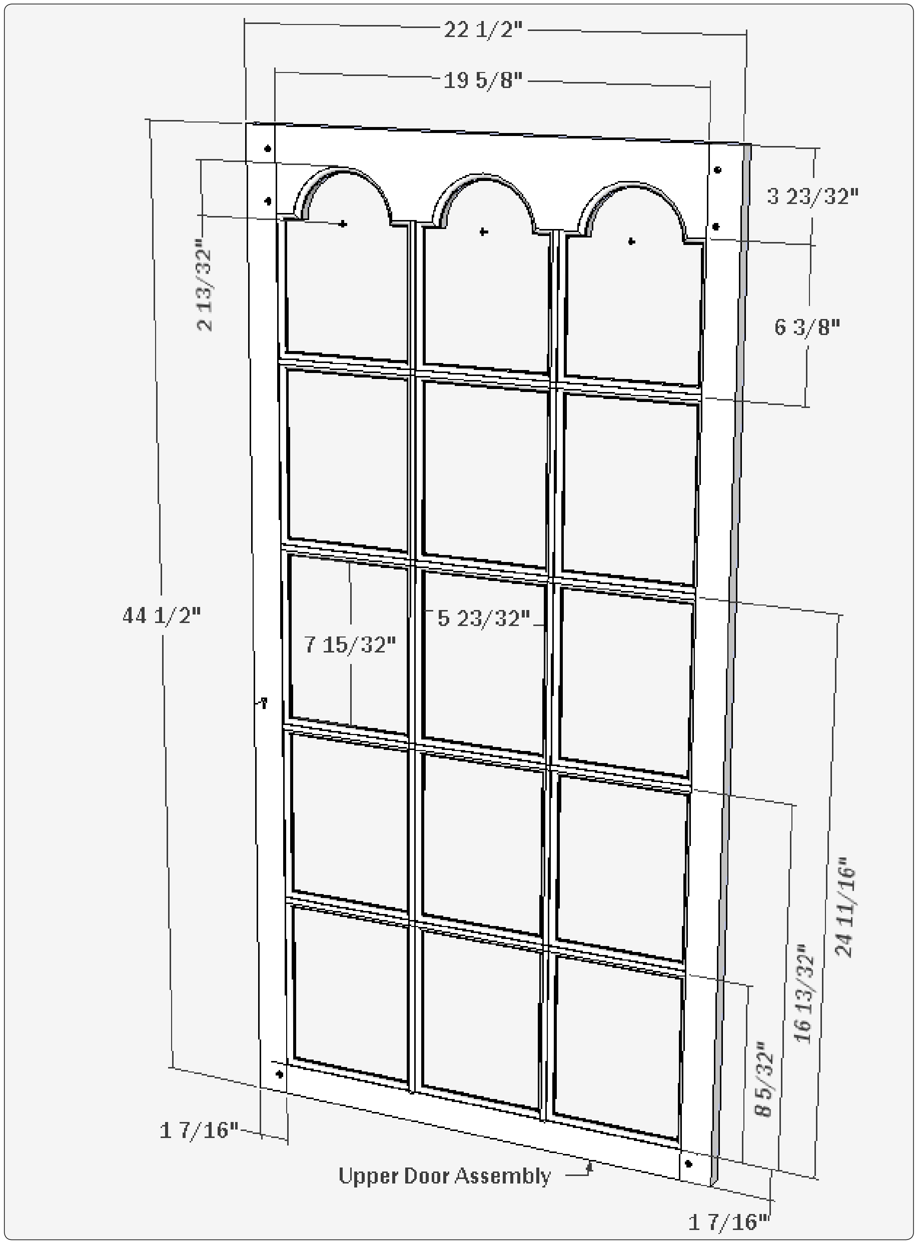


Figure 144. *The upper door assembly.*

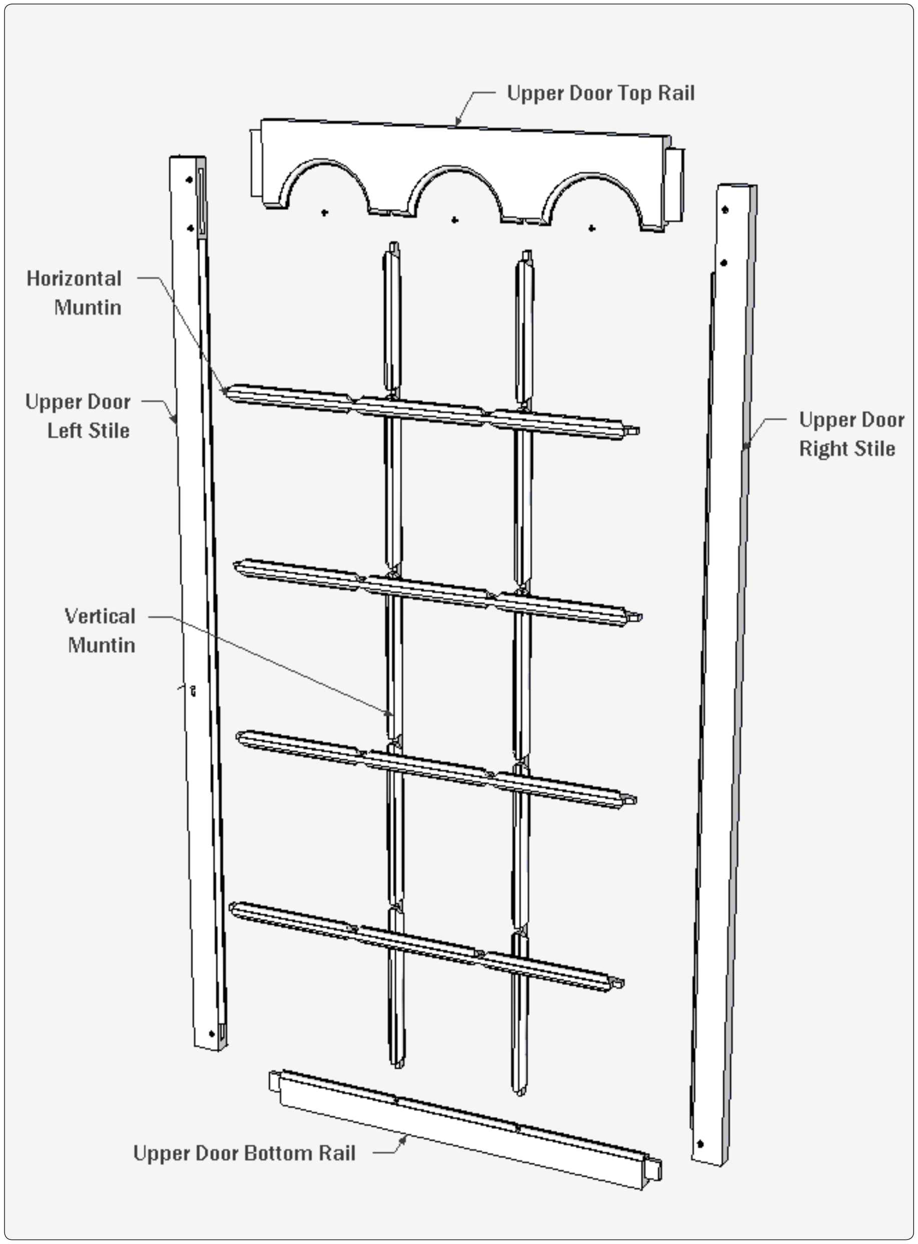
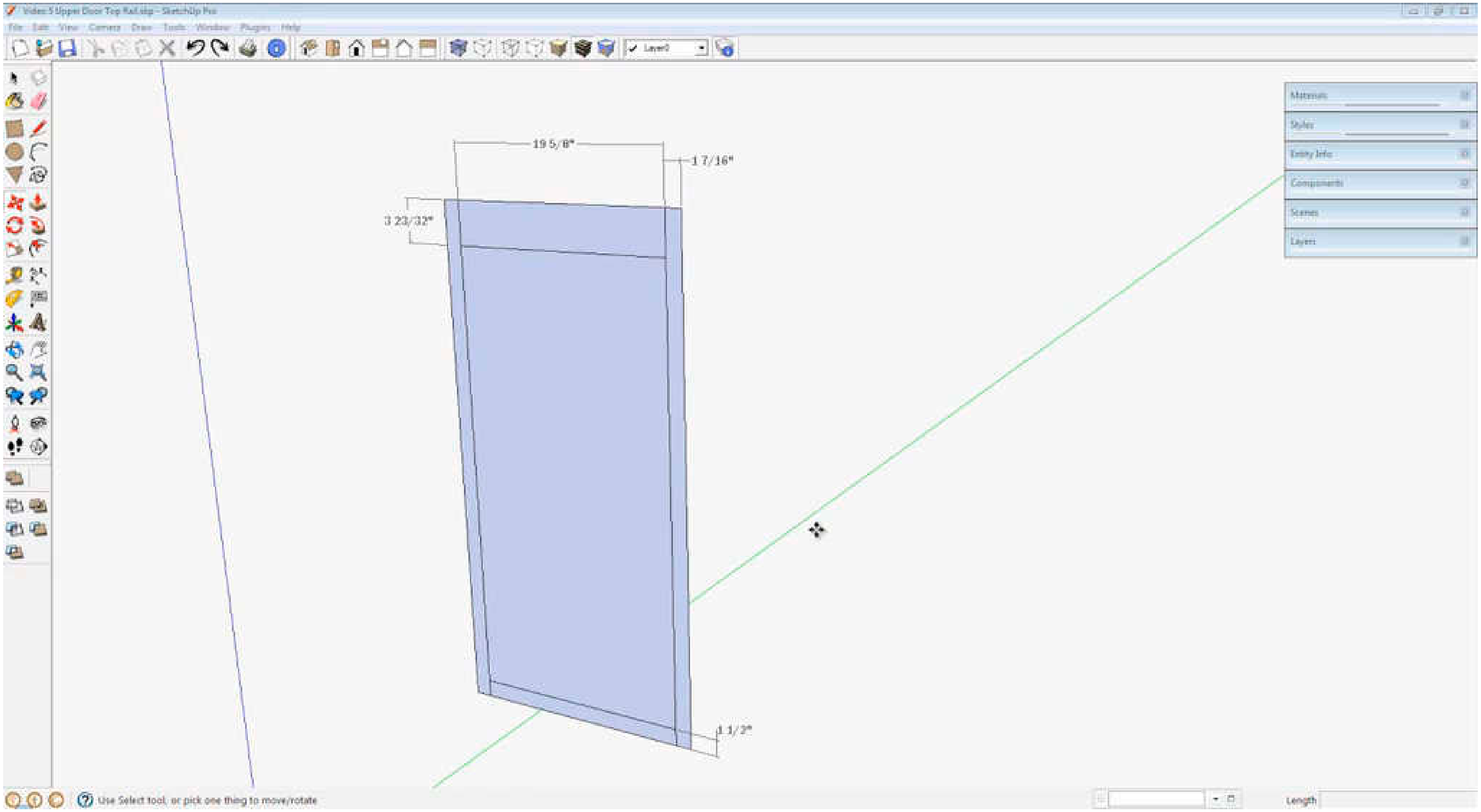


Figure 145. *An exploded view of the upper door.*

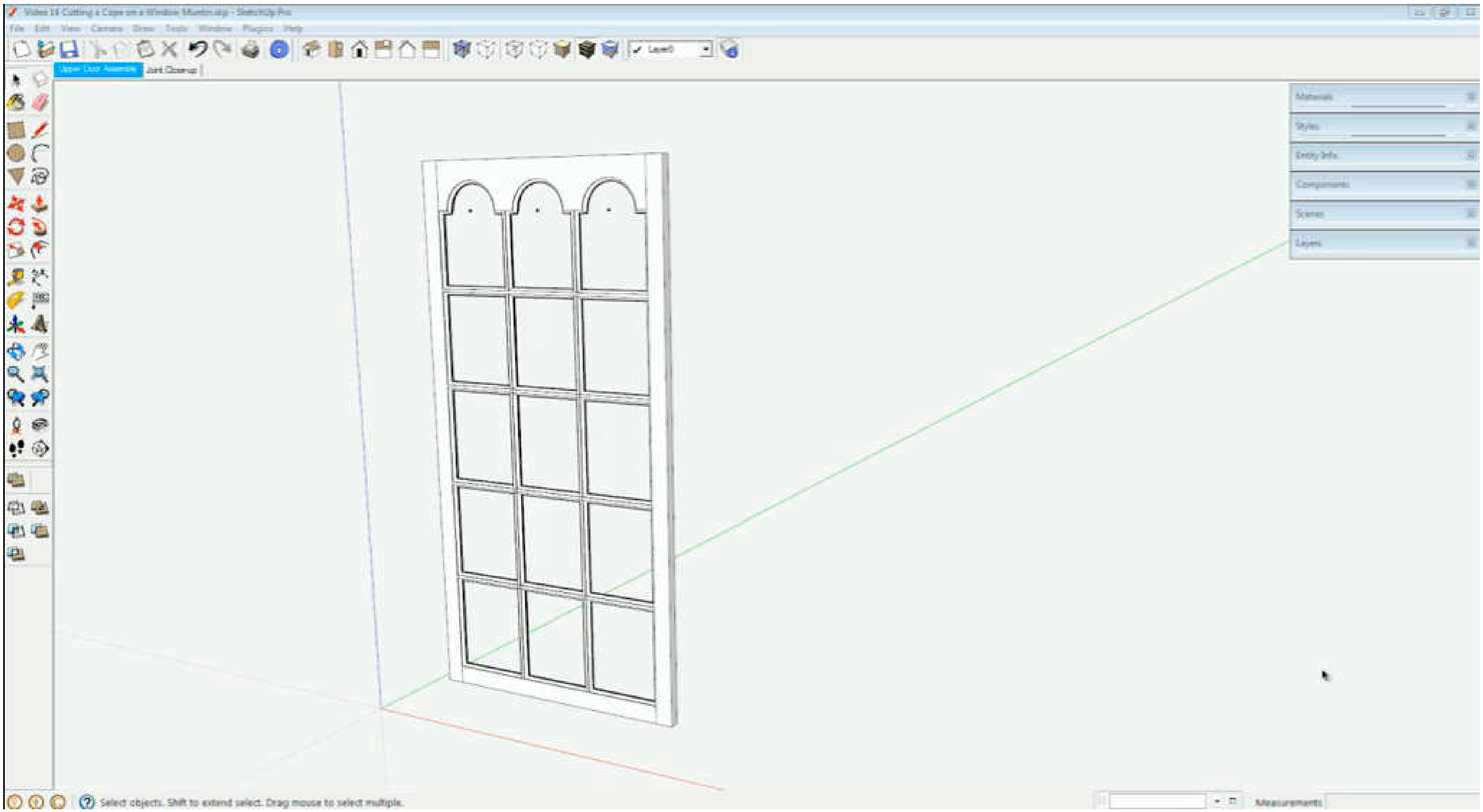
Video Tutorial: Making the Upper Door Top Rail

The upper door top rail, with its semicircular cutouts and thumbnail edge profile, is a challenging component. This video will show you a process for modeling it. (The accompanying text gives a slightly different method for locating the centers of the semicircular cutouts in the rail, but the end results will be the same no matter which method you follow.) As usual, the work begins with careful placement of guidelines. You create the cutout shapes with the Circle Tool. Then you position a door edge molding shape on the lower edge of the rail and extrude it with the Follow Me Tool. The last step is to add the tenons to the ends of the rail.



Video Tutorial: Cutting a Cope on a Door Muntin

Moldings like the muntins in the corner cupboard door are usually mitered or coped where two pieces intersect. In this 18th century piece, the cabinetmaker chose coped moldings. This video will show how to cope the end of the muntin to fit into the upper door rail. "Cutter" components take the place of a coping saw. Once you put the cutter in position, you intersect it with the muntin, then perform some clean-up to remove the waste edges and faces.



rails and stiles. Figures 144 and 145 show the completed door exploded as well as assembled and dimensioned. Refer to them as needed while you construct the door.

Step 51 As you did with the lower cabinet door, draw the upper door in place, beginning with a rectangle in the door opening. See Figure 146. Copy this rectangle and move it away from the carcase. Using the dimensions shown in Figure 144, place guidelines to mark the width of the stiles and rails. Trace over the guidelines with the Line Tool. Draw left-to-right selection boxes around the stile and rail shapes one by one, then make them components. Make each component 13/16 in. thick. Figure 145 gives the component names I used.

Step 52 Make a copy of the top rail and move it away from the model. Open the component for editing, then right-click on the lower front edge. Pick Divide from the menu, and divide the edge into 6 segments to help locate the center of the arches (Figure 149).

Use the Circle Tool to draw circles at the three arch locations. Margon specifies a radius of 2 13/32 in. radius. Delete the waste half of the circle and make the arch shape with the Push/Pull Tool (Figure 150).

Create the tenons on the top rail. They are ¼ in. thick, ¾ in. long, and have a ½-in. shoulder at each end. See Figure 151.

Step 53 Make a copy of the bottom rail and move it away from the model. Create the tenons. Like the ones on the top rail, these are ¼ in. thick and ¾ in. long. However, the ½-in. shoulder is only on the bottom end of

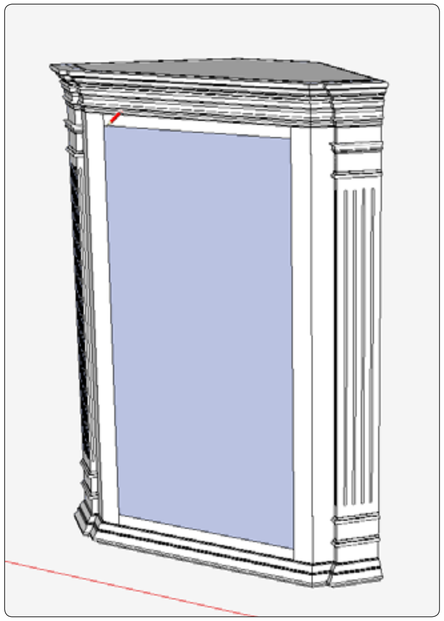


Figure 146. *Draw a rectangle in the door opening.*

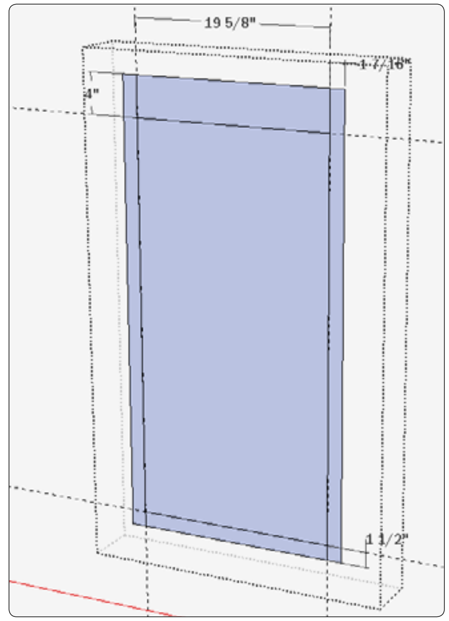


Figure 147. *Size the components with guidelines.*

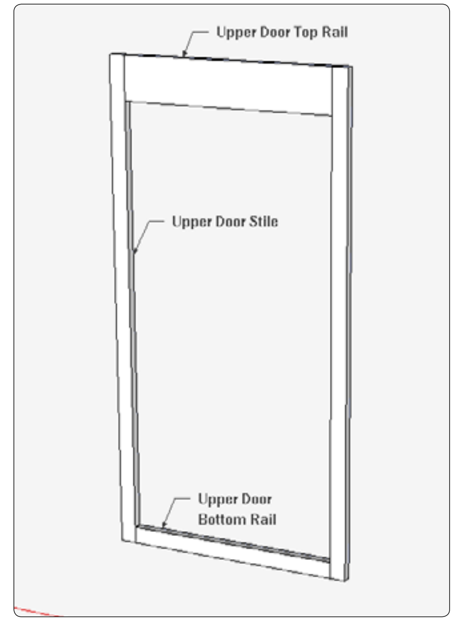


Figure 148. *Make each component 13/16 in. thick.*

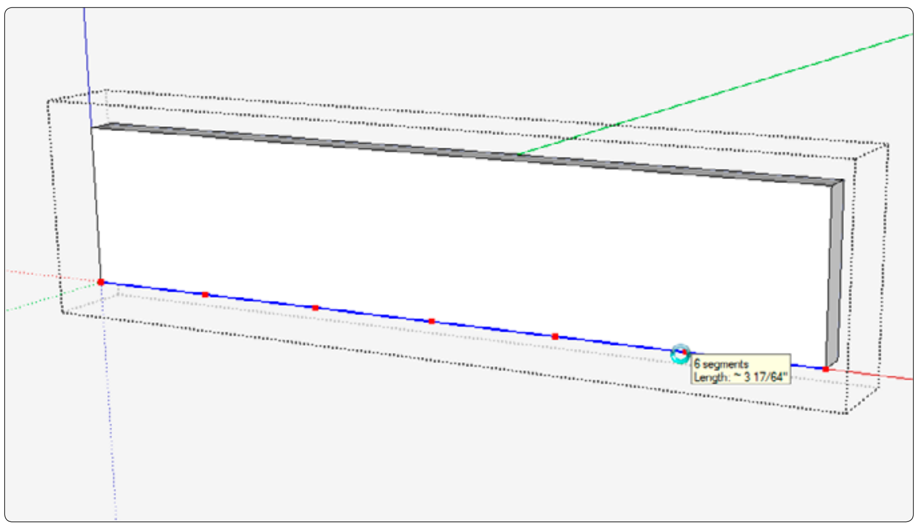


Figure 149. *Make a copy of the top rail. Divide the bottom edge into six equal segments to help place the arches.*

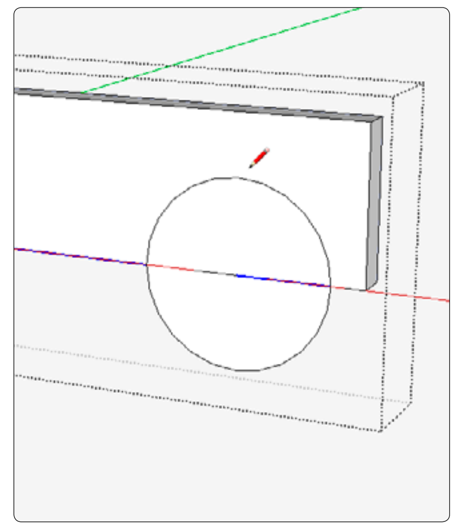


Figure 150. *Make the arches with the Circle Tool, then delete the lower half of the circle.*

the rail, as you can see in Figure 152. Delete the copies of the rails. The door frame to this point is shown in Figure 153.

Step 54 Use the rail tenons to make the mortises in the stile (Figure 154). Turn on X-Ray style, open the stile for editing, zoom in, and draw the outline of the tenon on the stile. Then use the Push/Pull Tool to create the mortise.

Step 55 The rails and stiles have a small molding on their front inner edges, as shown in Figure 155. Draw the isolated molding shape, as shown in Figure 156, and make it a component. Be sure to leave the 1/16-in. line segment extending beyond the face. This will be used to connect the molding shape to the stiles and rails precisely.

Open the stile for editing, then open the Component Dialog Box and retrieve a copy of the molding shape you just drew. Place it precisely in the corner where the stile meets the top rail. See Figure 157. Explode the molding shape and use the Push/Pull Tool to extend it along the length of the stile until it meets the bottom rail.

Step 56 Make a copy of the top rail and move it away from the model. Open this component for editing and retrieve another copy of the molding shape from the Component Dialog Box. Rotate it, and place it as shown in Figure 158.

Use the Follow Me Tool to add the molding shape to the inner edge of the arches. Place the shape on the inner edge and explode the shape. Choose the Select Tool while you press the Shift key to select the path: all the arches and the straight segments between

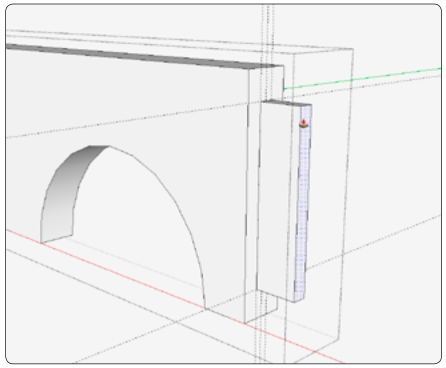


Figure 151. *Add tenons to the top rail.*

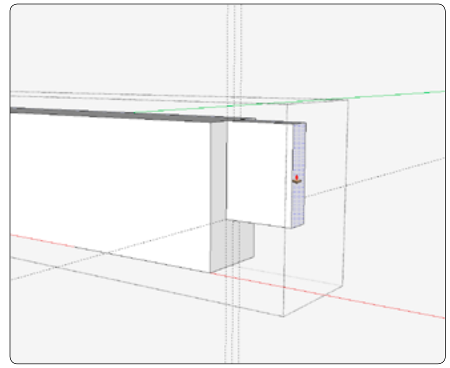


Figure 152. *Add tenons to the bottom rail.*

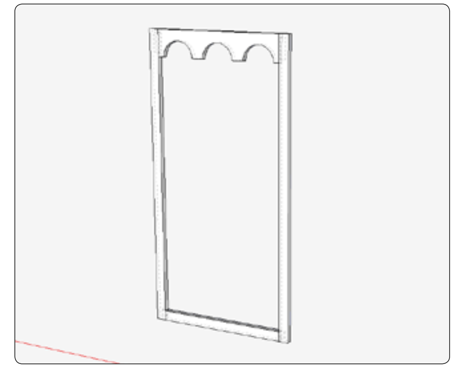


Figure 153. *The status of the door frame.*

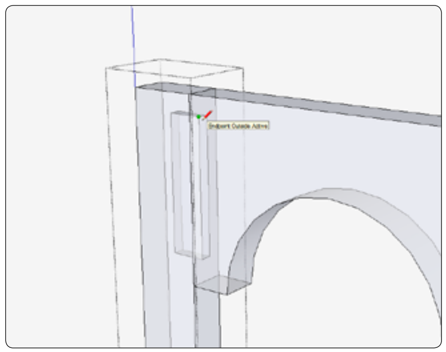


Figure 154. *Use the rail tenons to make the mortises in the stiles.*

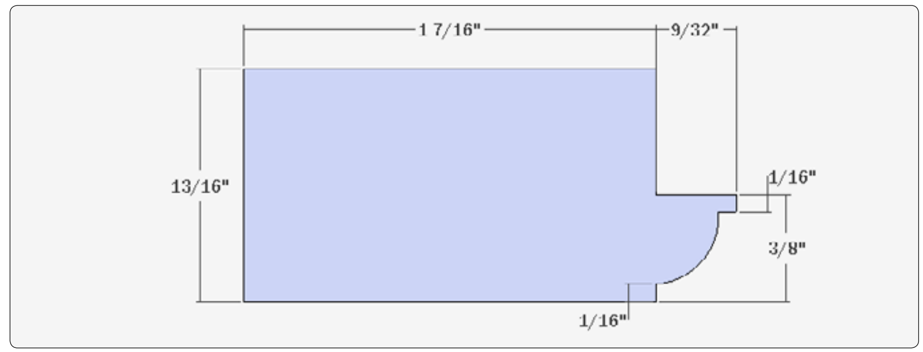


Figure 155. *A top view of the stile, showing the fingernail molding on the front inner edge.*

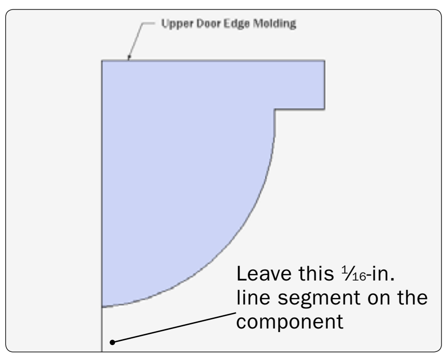


Figure 156. *Draw the fingernail molding shape and make it a component.*

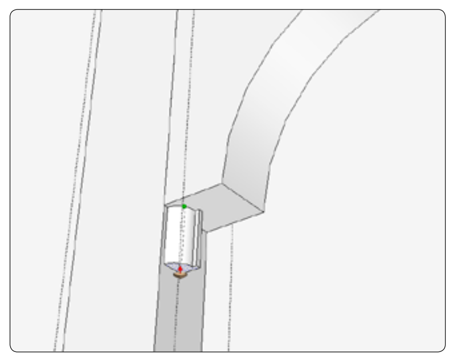


Figure 157. *Place the molding component in the corner and extrude it.*

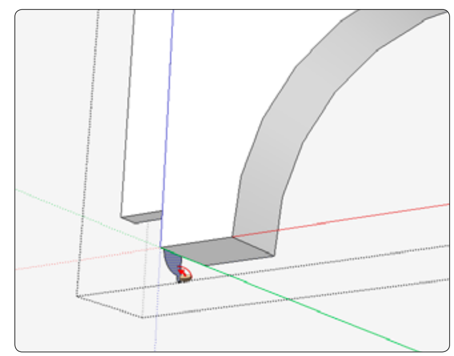


Figure 158. *Connect the molding shape to make a copy of the top rail.*

them. Choose the Follow Me Tool and click on the face of the molding shape to complete the extrusion.

Step 57 Open a copy of the bottom rail for editing and retrieve another copy of the molding shape from the Component Dialog Box. Rotate it into position and place it on the end of the rail, as shown in Figure 159. Explode the shape, then use the Push/Pull Tool to extend it the length of the rail.

Step 58 Follow the procedures explained in steps 31 and 32 to create coped joints in the corners where the stiles and rails meet.

Step 59 Use the top view of the stile (Figure 155) to make the muntin. Reduce the left-to-right size of that shape to 13/16 in. Copy the shape, flip it, then move the copy so that it overlaps the original. The combined shape should be 13/16 in. wide and 13/16 in. deep, as shown in Figure 162. Explode both components and remove the waste to produce the muntin cross-section shape shown in Figure 162.

It helps to shift the axis location on the muntin shape to the midpoint of the top edge, as shown in Figure 163. To do that, right-click on the component and select Change Axis, Then set the axes at the preferred location.

Step 60 Select the muntin shape component from the Component Dialog Box and place it on the midpoint of the rail's edge, as shown in Figure 164. Explode the component and make it a new component. Use the Push/Pull Tool to extend it the full length of the door, stopping at the top front edge

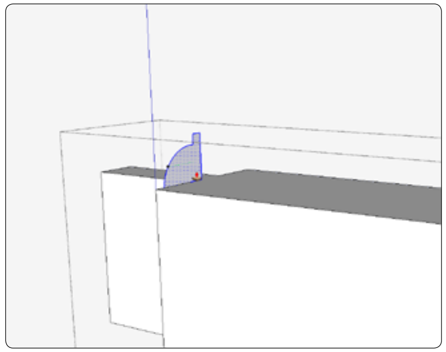


Figure 159. *Create the inner edge molding shape on the bottom rail.*

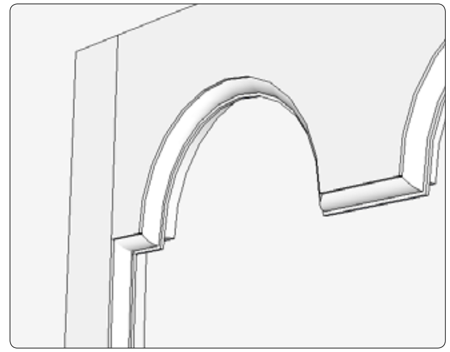


Figure 160. *The molded inner edges are complete. The corners must now be coped.*

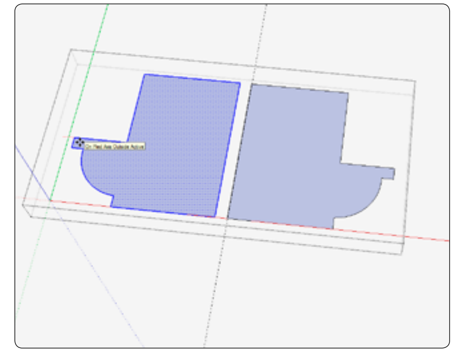


Figure 161. *Use a top view of the stile to make the muntins.*

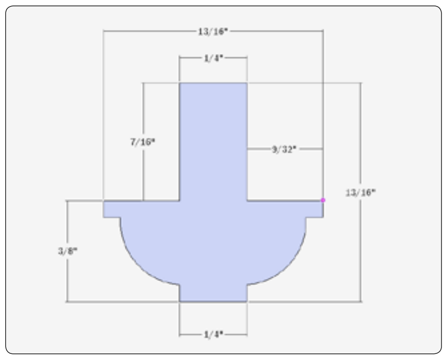


Figure 162. *The completed muntin shape.*

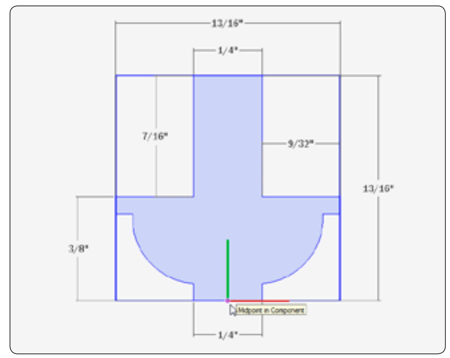


Figure 163. *Shift the axes of this component to the midpoint.*

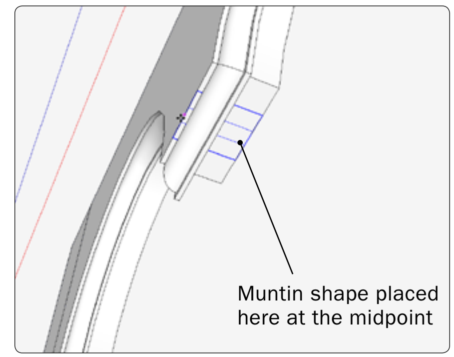


Figure 164. *A top view of the stile, showing the molded shape on the front inner edge.*

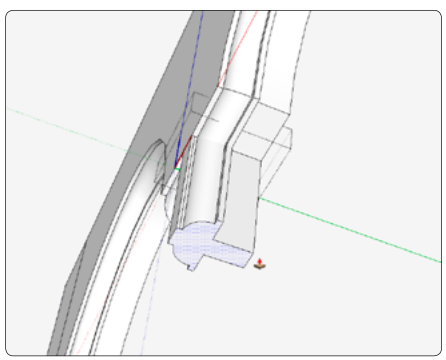


Figure 165. *Use the Push/Pull Tool to extend the vertical muntin shape.*

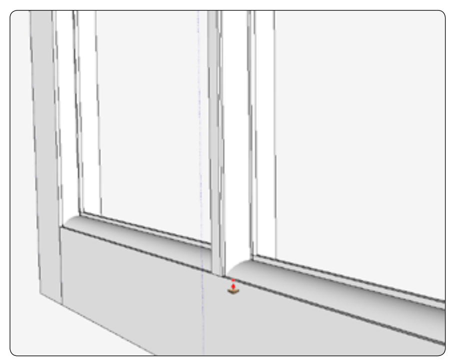


Figure 166. *End the move at the top front edge of the lower rail.*

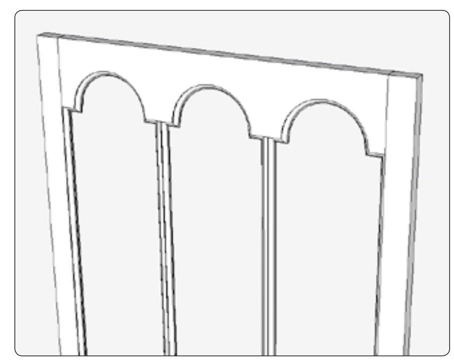


Figure 167. *Copy the muntin and move it to the next space between arches.*

of the bottom rail, as shown in Figure 166. Copy the vertical muntin and move it over to the other location on the door frame. See Figure 167.

Step 61 Next, create the horizontal muntins using that same shape and technique. Following the dimensions shown in Figure 144, place horizontal guidelines to mark the centerlines of the horizontal muntins. See Figure 168. Pull a copy of the muntin shape from the Component Dialog Box and move it close to the stile. Rotate it 90 degrees and place on the stile at the guideline. Click on the muntin shape, explode it, and make it a component with a new name.

Use the Push/Pull Tool to make the horizontal muntin its full length. Pull it right through the two vertical muntins (Figure 169) and stop the movement at the front edge of the opposite stile (Figure 170). Copy the horizontal muntin to the other three locations, as shown in Figure 171.

Step 62 So far we have not done anything about the joinery of the muntins. Their ends could be coped or, as an alternative, cut at an angle to fit in matching cuts in the rails and stiles. I'll show both options.

As shown in Figure 172, make a muntin cutter component that can be used to trim the ends at a 45-degree angle. Copy one of the vertical muntins and move it away from the model. Open the muntin for editing, grab a muntin cutter from the Component Dialog Box, and place it on the end of the muntin, as shown in Figure 173. Explode the cutter, select all of the muntin, and execute an Intersect Faces with Selection command. Use the Eraser Tool to remove the waste,

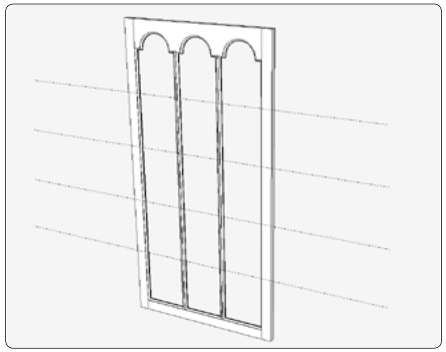


Figure 168. *Make guidelines at the centerline locations of the horizontal muntins.*

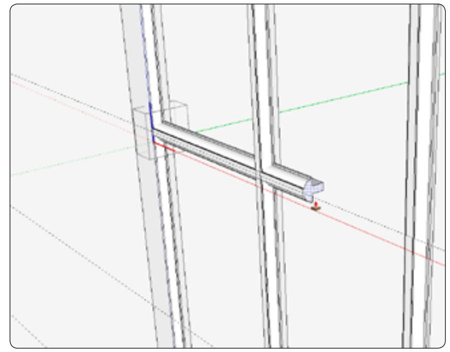


Figure 169. *Position the muntin shape and pull it to length.*

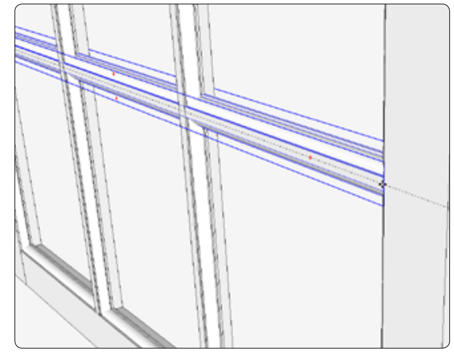


Figure 170. *Stop the movement at the front edge of the opposite stile.*

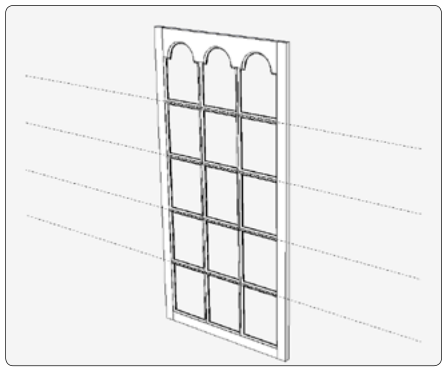


Figure 171. *Copy the horizontal muntin to the other three locations.*

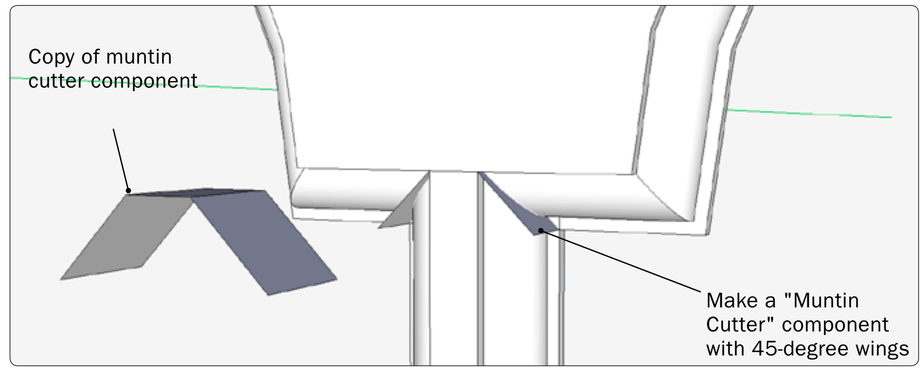


Figure 172. *Create a muntin cutter and position it where the muntin meets the rail.*

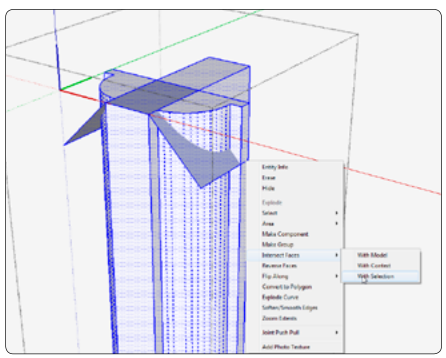


Figure 173. *Intersect the muntin and muntin cutter to begin mitering the ends.*

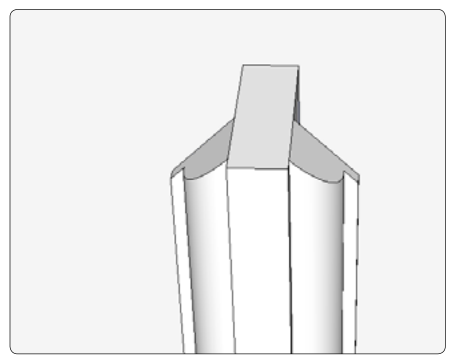


Figure 174. *The finished cut on the end of the muntin.*

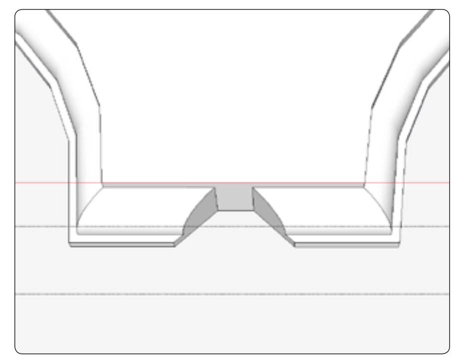


Figure 175. *The matching V-cut for the muntin in the top rail.*

producing the shape shown in Figure 174. Use the muntin cutter to make a V-cut in the rail, as shown in Figure 175. Again, explode the cutter, select all of the rail, and do an Intersect command.

To make coped joints, as Margon shows, you need a cope cutter like the one used for the lower-cabinet door. However we cannot reuse that one because the molding profile is different for the upper door.

Use the upper door edge molding shape to create the upper cope cutter component. As Figure 176 shows, the component has two shapes separated by a ¼-in. gap.

Open one of the vertical muntins for editing and grab a copy of the upper cope cutter from the Component Dialog Box. Rotate the cutter and place it onto the top edge of the muntin, as shown in Figure 177. Explode the cutter. Triple-click on the muntin to select it all, and execute an Intersect Faces with Selection command. Clean up the waste, as shown in Figure 178. Repeat this procedure on both ends of the vertical and horizontal muntin components.

Step 63 The rails and stiles require a ¼-in.-wide gap in the inner molded edge to accommodate the end of the muntin. Make that with the cutter shown in Figure 179.

Place this cutter on the midpoint where the muntin meets a stile or rail. See Figure 180. Explode the cutter and execute an Intersect Faces with Selection command. After clearing away the waste, you should see the gap as shown in Figure 181. Repeat at all the muntin connecting points.

Step 64 The muntins connect to the stiles and rails with a small mortise-and-tenon

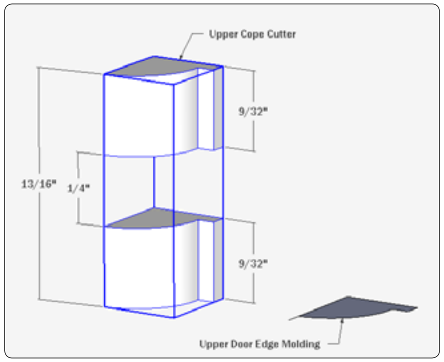


Figure 176. *Create an upper cope cutter using the door molding component.*

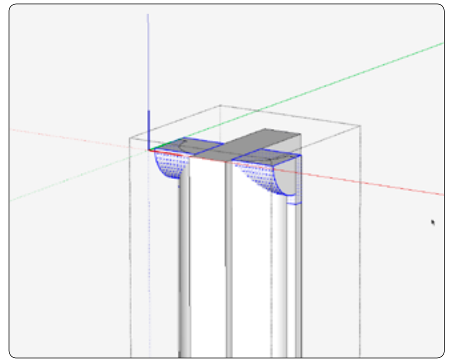


Figure 177. *Position the cope cutter in the end of the vertical muntin.*

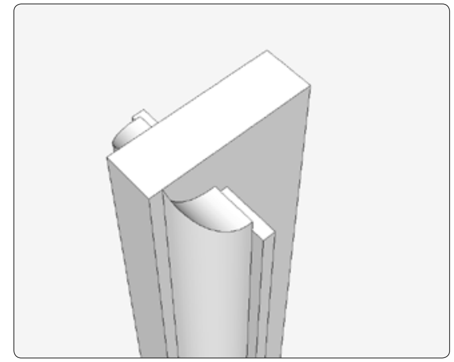


Figure 178. *Clean up the waste after the intersection.*

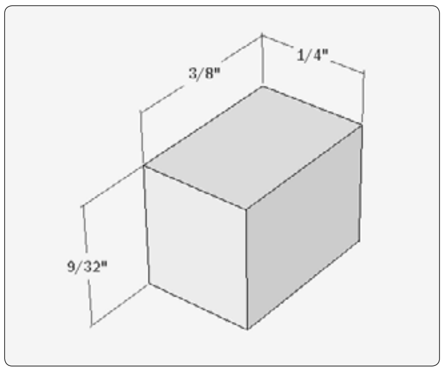


Figure 179. *Make a rail and stile cutter.*

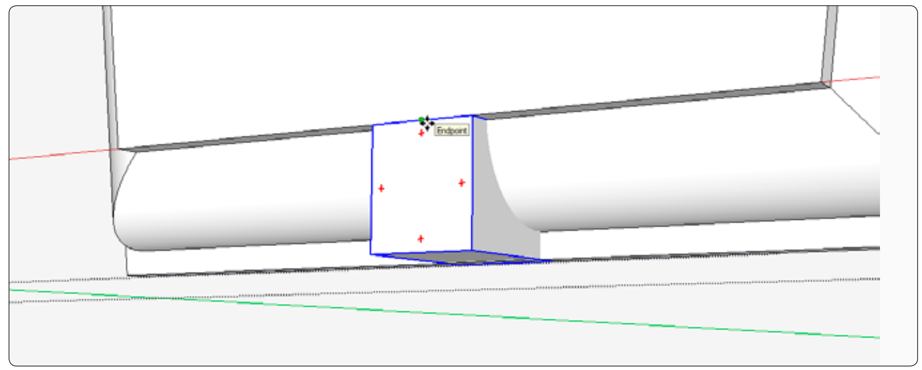


Figure 180. *Position the cutter at the midpoint of the muntin connection and execute an Intersect Faces with Selection command.*

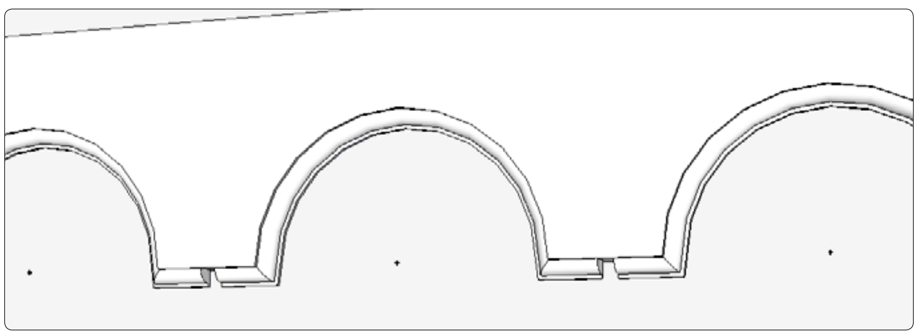


Figure 181. *After the intersection and cleanup, you will see gaps in the rail where the muntins will fit.*

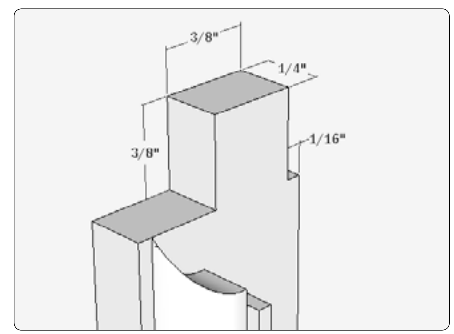


Figure 182. *Create a tenon on the ends of the muntins.*

joint. Figure 182 gives the dimensions for this stub tenon. Add the tenon to each end of the vertical and horizontal muntin components.

Connect the vertical muntin with the top rail, as shown in Figure 183. Open the rail for editing and use the tenon to create the ⅜-in.-deep mortise in the rail. Make a mortise at each connection between a muntin and a stile and rail.

Step 65 The horizontal and vertical muntins intersect at eight points. You need to make a crosslapped joint at each one of those points, using the muntin cutter shown in Figure 161.

Open a horizontal muntin component for editing. Grab the muntin cutter from the Component Dialog Box and place it at the joint, as shown in Figure 184. Copy the cutter, flip it, and move it into position on the other side of the joint. Explode the cutters, select all, and execute an Intersect Faces with Selection command. After you clean up the waste, the muntin should look like the one shown in Figure 185.

Repeat these operations on a vertical muntin, as shown in Figures 186 and 187.

To finish the joint in the vertical muntin, use the Push/Pull Tool to push in the front half of the center spine; begin the move, type 13/32, and press Enter. See Figure 188. Do the same on the horizontal muntin, clearing away the back half of the center spine as shown in Figure 189. Now the two crossing muntins will join together as shown in Figure 190.

Create this crosslap joint at all the intersections of the horizontal and vertical muntin components. Draw a left-to-right

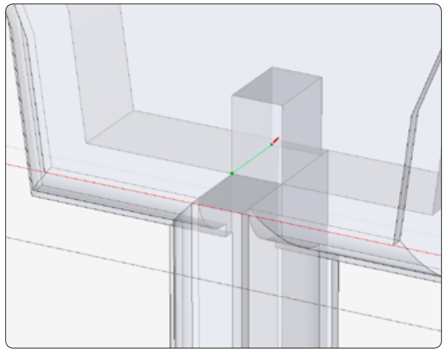


Figure 183. *Create the mortise in the top rail using the muntin tenon as reference.*

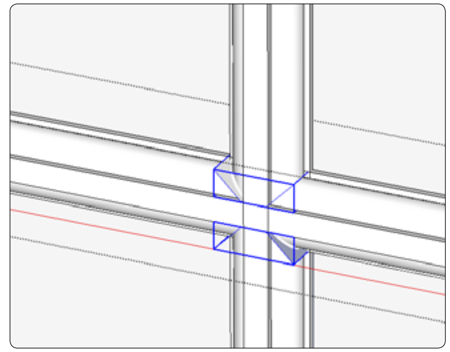


Figure 184. *Position two muntin cutters at the joint, then explode the cutters.*

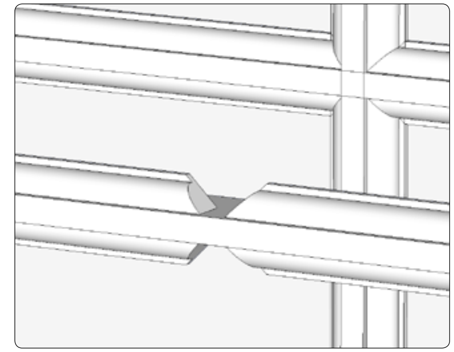


Figure 185. *After the intersection, clean up the waste on a copy of the horizontal muntin.*

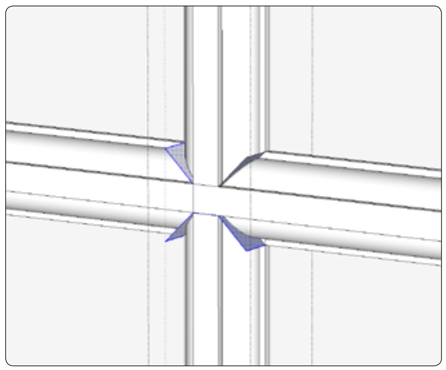


Figure 186. *Edit the vertical muntin and place two muntin cutters.*

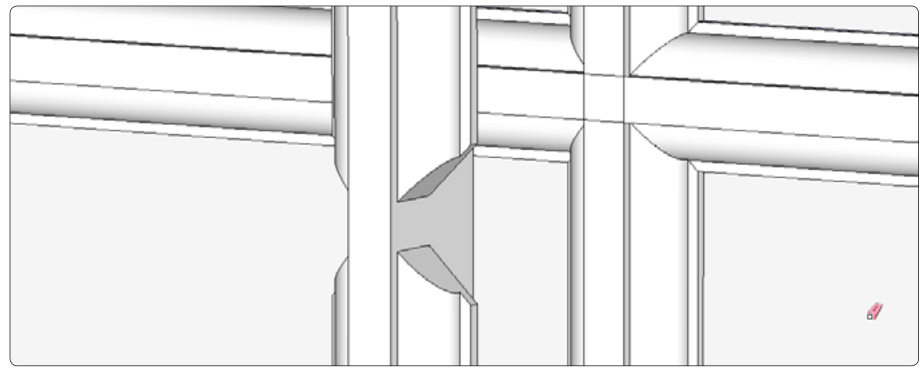


Figure 187. *The results of the Intersection on the vertical muntin joint.*

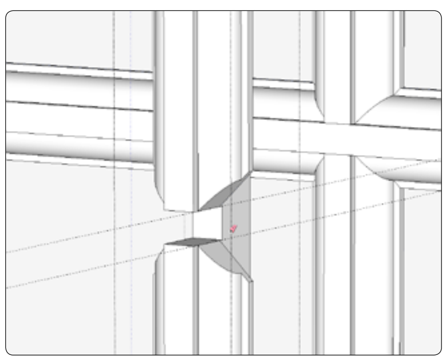


Figure 188. *Remove the front half of the center spine on the vertical muntin.*

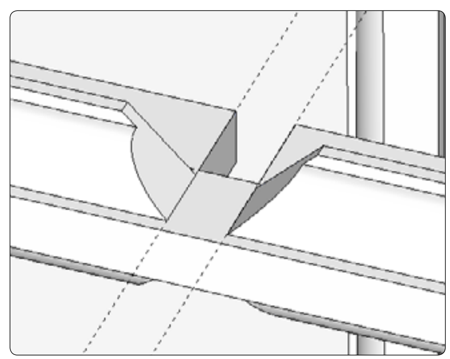


Figure 189. *Remove the back half of the center spine on the horizontal muntin.*

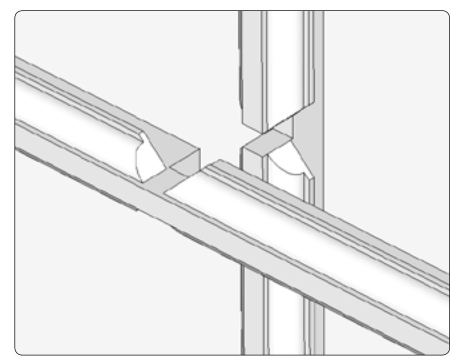


Figure 190. *The finished crosslapped joint.*

selecton box around the entire joint and copy it to the other locations.

Step 66 To add some realism, create a pane of glass. It is ⅛ in. thick and "painted" with Translucent_Glass_Grey, one of the standard materials from the Materials Dialog Box. Apply it by selecting the entire pane, then choosing the material and clicking on the pane with the Paint Bucket Tool. Copy the glass to all the other spaces in the door.

Use the Follow Me Tool to create a ¼-in. quarter-round molding to back the glass. Figure 191 shows the completed molding in one panel.

Step 67 The left stile requires a rabbet ⅜-in· by ½-in. on its inside edge, as shown in Figure 192. The rabbet is stopped to accommodate the door lock, which is the same type used on the lower-cabinet door. Before editing the left stile, explode it and make it a component with a new name. Create a keyhole and a shallow recess on the edge of the stile to mount the door lock.

This completes the corner cupboard.

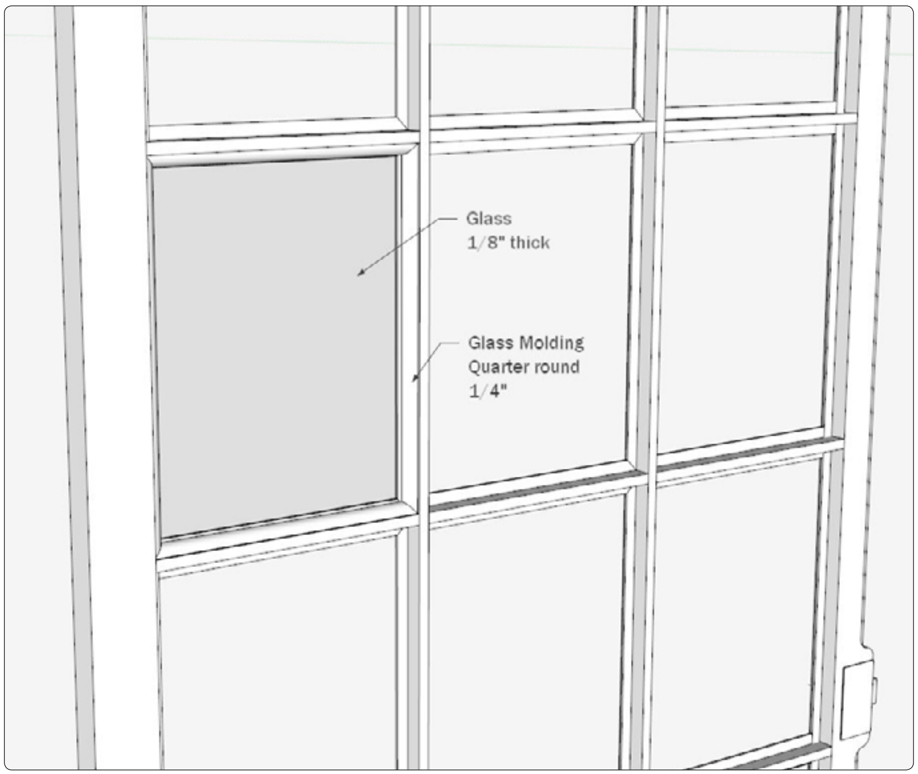


***Figure 191.** A rear view of the assembled upper door, with one pane of glass and a backing molding of ¼-in. quarter-round.*

***Figure 192.** A rear view of the assembled upper door, showing the stopped rabbet, the door lock, and the keyhole.*

How to Adjust and Resize Components and Models

For centuries, good cabinet-making shops have had dozens of patterns and templates hanging from the rafters. They would be used to create multiples, such as a set of dining chairs. They would also be used for new customers who wanted an existing design.

I'm reminded of the late Sam Maloof's shop, which had countless labeled templates covering the walls. He made many variations of his "standard" products, yet took advantage of work already done by having these valuable assets close at hand.

SketchUp can produce full-size templates, and I will show you how in the next chapter. Just as important, SketchUp also lets you keep a storehouse of specific components and entire pieces that can be reused or altered—scaled, stretched, or shrunk—to be transformed into something new.

The project in the previous chapter introduced the concept of reusing components. The time needed to stretch the lower-cabinet components to create the upper cabinet is a small fraction of that required to draw new components from scratch.

I can also save time by keeping my preliminary models and components. I typically produce five or six design variations before arriving at one ready for the shop. The design process involves a significant amount of resizing and adjusting, and I save each stage of development. Occasionally, I need to revert to a previous version, and I'm very glad to have kept the file.

With SketchUp, the assets are available at the tap of a mouse. The more models you create, the more assets you have for future projects. Items like doors, drawers, legs, handles, hardware, moldings, rails, stretchers, backs, arms, skirts, and panels can be reused, modified, and applied to new designs.

SketchUp provides a mechanism for filing and grouping your component assets. Figure 1 shows the Components Dialog Box and the option to open or create a local collection. When you click on the Details icon, this option appears in the fly-out menu. When you pick that option, a Browse for Folder box appears. See Figure 2. Create a file location here for your local collection. For example, I have a folder called My Drawers for the collection shown in Figure 3. To add to the collection, I click on a drawer assembly in a SketchUp file, right-click on the selection, and choose Save As in the pop-up menu. (The screens look different on Macs, but the process is essentially the same.)

In this chapter, I'll show you how to adjust and resize components and models. Using models created in the earlier chapters, I'll develop new, larger furniture pieces by stretching and adapting existing components. These new models, while substantially complete, won't be fully detailed plans. Their purpose is to show you how to get there in the most efficient way.

For this work, the Move/Copy Tool is the best choice. As an alternative, you can use the Scale Tool to resize components. However, as the sidebar on the next page shows, you have to be careful because scaling a model usually leads to some unwanted changes.

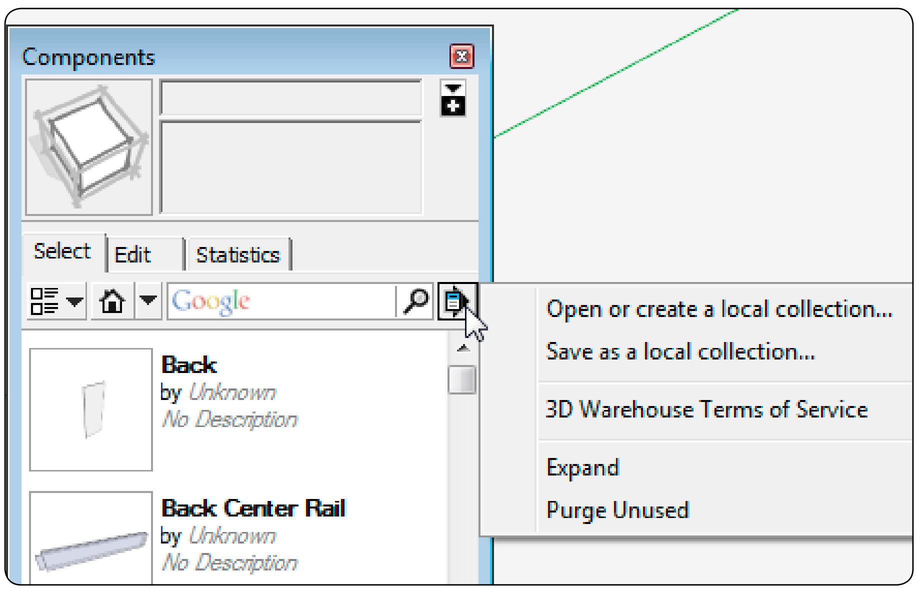


Figure 1. *The Components Dialog Box option to open or create a local collection.*

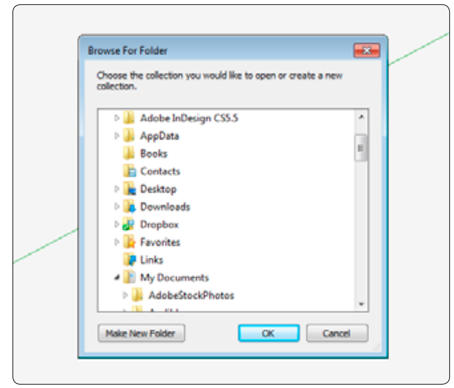


Figure 2. *The Browse for Folder box. Create a file name and location.*

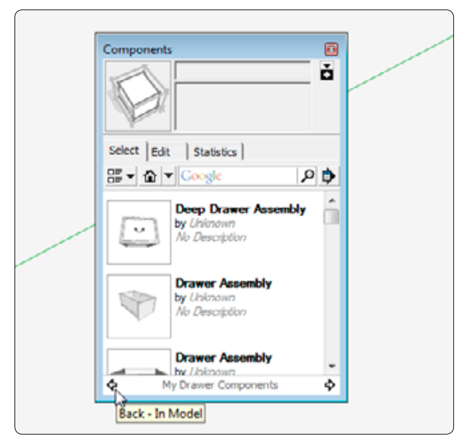


Figure 3. *My Drawers local collection.*

The Scale Tool: Its Uses and Limitations

To understand how the Scale Tool works, use a copy of the side drawer assembly from the Arts and Crafts bookcase from chapter 4. Draw a left-to-right selection box around the entire drawer assembly and choose the Scale Tool.

As Figure 4 shows, you will immediately see 27 green grips surrounding the drawer. Hover the Scale Tool icon over any the grips and notice the prompts that appear, such as "Red Scale about Opposite Point." It indicates the type and direction of scaling when you use that grip. Click on various grips and move the mouse to observe changes in the drawer. When you choose a corner grip, the scaling is uniform about all axes and the overall size will grow uniformly in width, length, and depth. For example, type the number 2, press enter, and the drawer will double in size.

The side drawers in this cabinet are 14¾ in. wide, but the middle drawer is 15 in. Can you use the Scale Tool to quickly make the middle drawer by scaling up a side drawer? Maybe, as this demonstration will show.

Click on the middle grip in the side of the drawer, as shown in Figure 5. Pull the grip along the red axis and notice how only the drawer's width changes. Click the mouse again to stop the growth. It doesn't matter how much the drawer has been stretched. Now type 15" and press Enter. Be sure to type a quotation mark for the inch sign after typing 15. If you don't, you will make the model 15 times larger.

The drawer looks good and is exactly 15 in. wide. If you checked the dovetail joints, they would look perfectly fine. The drawer bottom looks good, too.

But there are some small problems, as you can see in Figure 6. The drawer pull should be 3¾ in. wide but has grown to 3$\frac{13}{16}$ in. The side is now $\frac{41}{64}$ in. thick rather than the original ⅝ in. You could ignore those changes because they are so small. Or, you can change the level of precision for dimensions, so that the drawer thickness will show as its original ⅝ in.

In this instance, it is feasible to use the Scale Tool to widen the drawer by ¼ in. Still, I think it is safer and more accurate to use the Move/Copy Tool instead. Overall, I think the Scale Tool has limited practical use when resizing components. Also, when you create a new assembly by resizing an existing component using Scale, you must first explode and rename all the pieces that you intend to scale. If you don't, you will only change the size of the copy, and the original component definition will be unchanged.

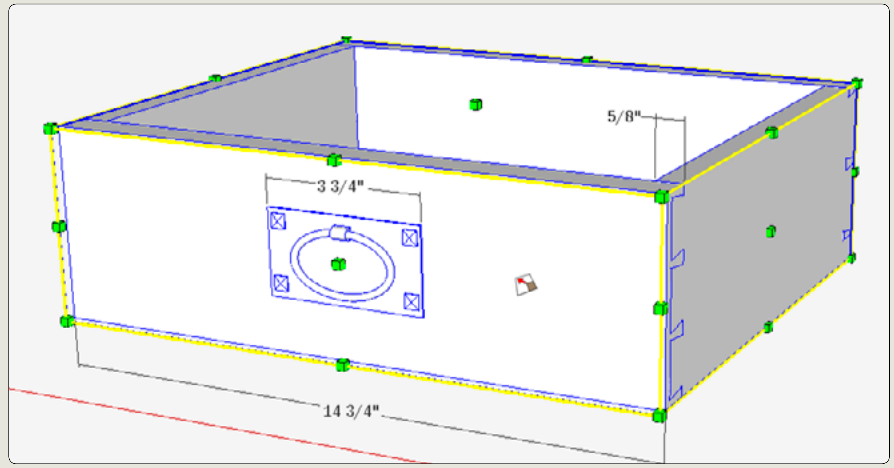


Figure 4. *The side drawer assembly surrounded by the green Scale Tool grips.*

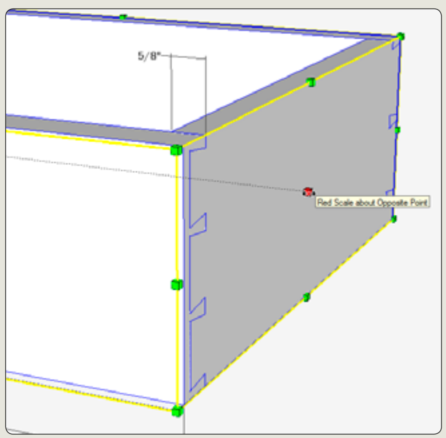


Figure 5. *Click on the middle grip in the right side of the drawer.*

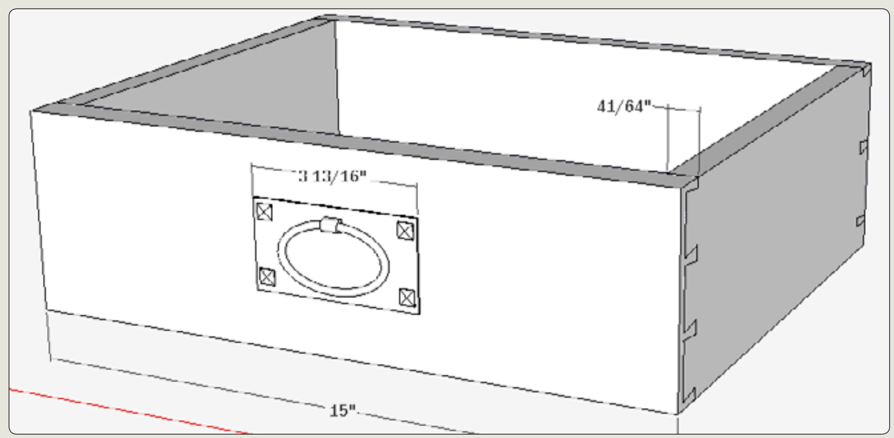
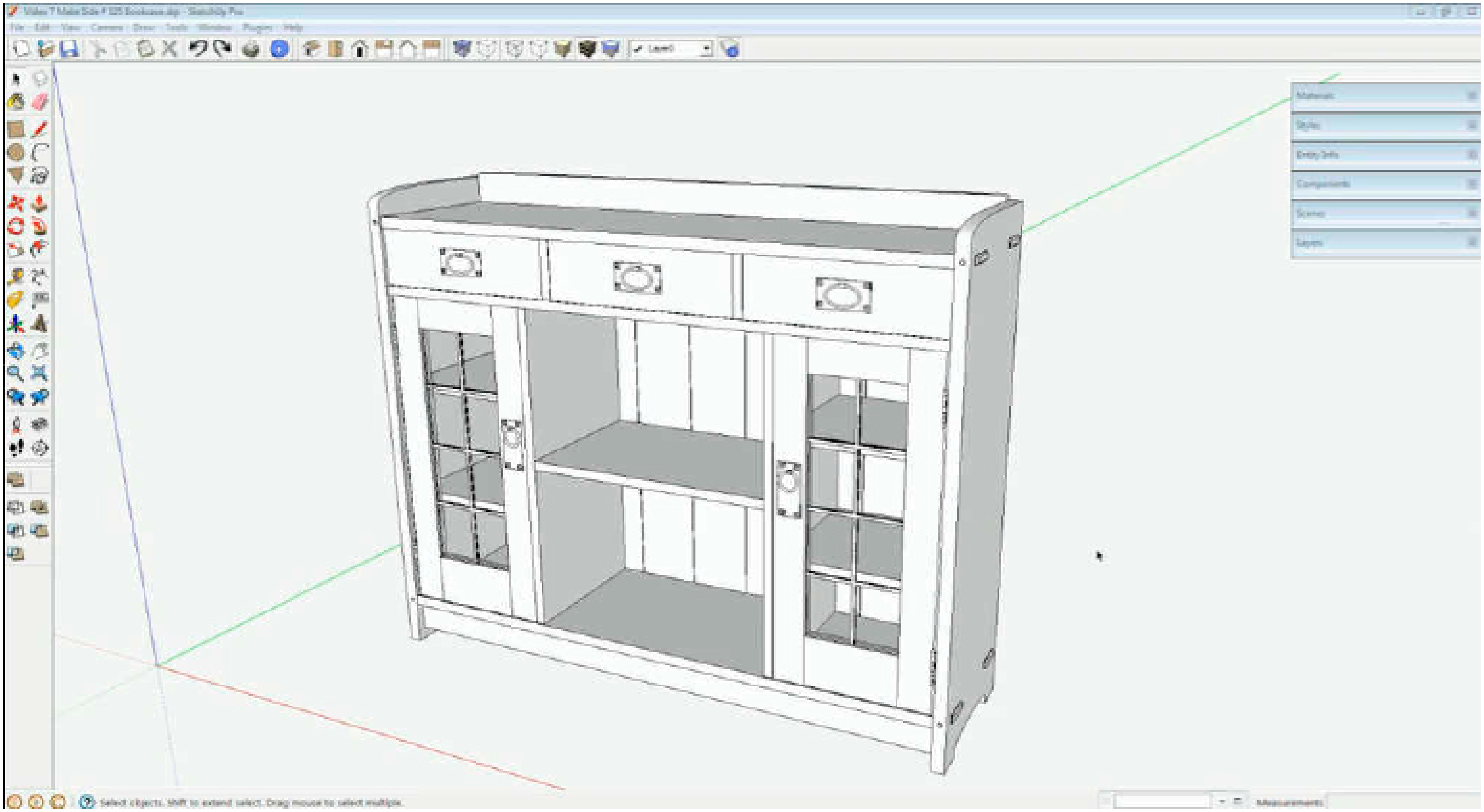


Figure 6. *The result of scaling on the red axis only to grow the width of the drawer by ¼ in.*

Video Tutorial: Making the Side for the #525 Bookcase

This video will show you how to begin the conversion of the display case to create a model of the much larger Stickley #525 Bookcase. After you perform some clean-up and delete some unneeded components in the original model, you stretch the side to a longer length while preserving some of the joinery. The Move/Copy Tool is key to making this type of modification successful.



Convert the Arts and Crafts cabinet to a Stickley bookcase

The first example of a conversion changes the Arts and Crafts cabinet from Chapter 4 to a larger double-door bookcase that was a standard catalog offering by Gustav Stickley in the early 1900s. He called it the #525. This exercise shows how a design can change and evolve, sometimes radically, without altering the basic style of the piece.

Figure 7 shows the two pieces side by side. They look quite different but have much in common: the sides, backsplash, back panel, and skirts, as well as the associated joinery. These similarities simplify the conversion.

From published information available on the Internet (I don't have access to drawings) the overall dimensions of the #525 bookcase are 51 in. wide, 55½ in. high, and 13 in. deep. The wedged tenons make it 3 in. wider than the display cabinet. It is 17 in. taller, but the two pieces are the same depth. A box of this size is overlaid on the original piece and shown in Figure 8.

Here is how to make the conversion:

Step 1 Make a copy of the Arts and Crafts cabinet. Open a new SketchUp file and paste the copy in it. The #525 bookcase will not have vertical partitions, drawers, and short shelves, so you can select those items and delete them. Also delete one of the doors. Figure 9 shows the resulting components that will be reused and refitted in the new bookcase.

Step 2 Place a guideline 55½ in. up along the blue axis from the bottom edge of the side, marking the height of the bookcase. With the Select Tool, click on the top and the

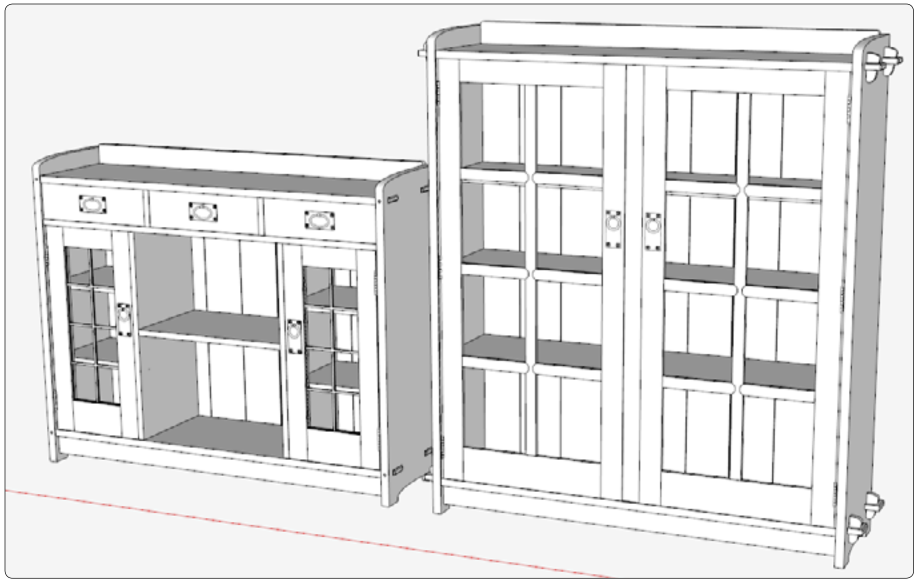


Figure 7. *The cabinet on the left was used to create the Stickley #525 bookcase.*

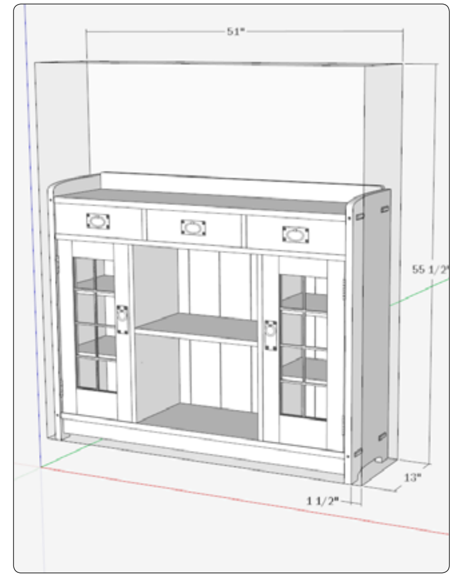


Figure 8. *The boundary of the #525 bookcase overlaid on the original cabinet.*

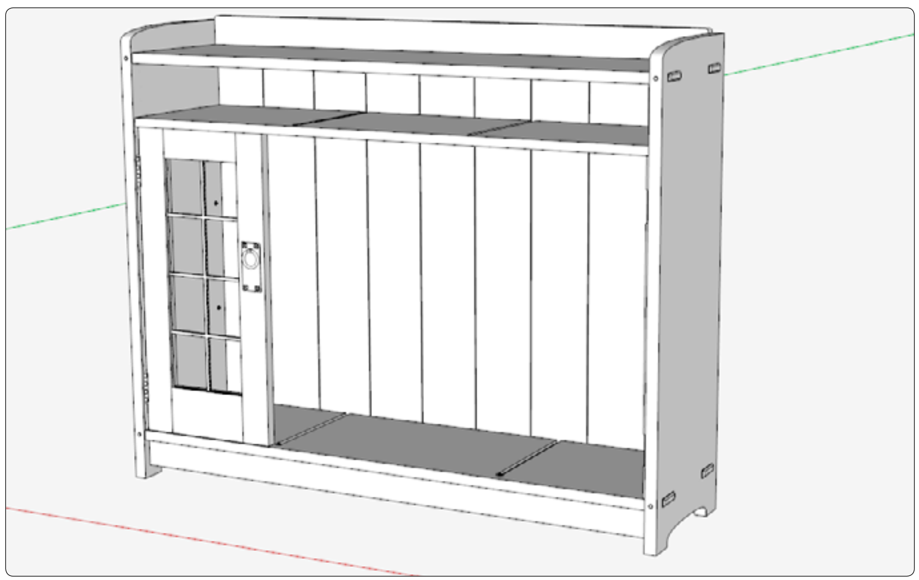


Figure 9. *On a copy of the cabinet assembly, erase the parts not used in the bookcase.*

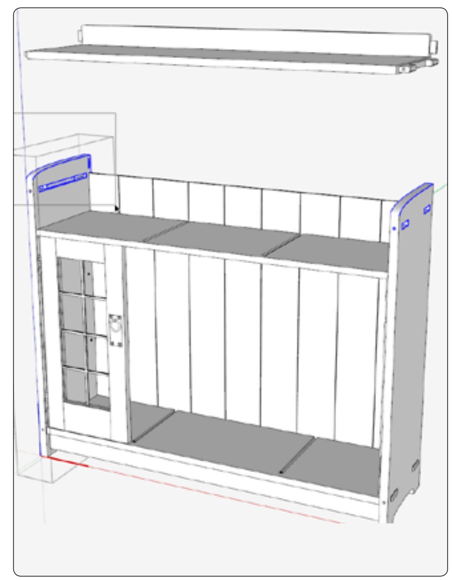


Figure 10. *Move the top and backsplash.*

backsplash. Choose the Move/Copy Tool, click on the top edge of the backsplash, and begin moving those components up. Tap the up or down arrow key to constrain the movement to the blue axis. Raise the two components up to the guideline, as shown in Figure 10.

Step 3 Open the side component for editing. Draw a left-to-right selection box around the upper portion of the side, as shown in Figure 11. Be sure that the selection box includes the mortises.

When you select portions of components in this way, it is critically important to capture all the necessary edges and faces. Orbit, pan, and zoom so you can easily see what you have selected. It is often helpful to turn on X-Ray style to give yourself a better view of the selection.

Choose the Move/Copy Tool and click on the upper edge of the mortise. Pull the side up along the blue axis (tap the up or down arrow key to constrain the move), and stop the movement when the top of the mortise meets the upper edge of the tenon on the top component. See Figure 12.

Step 4 The back slats also need to be lengthened. There are two components in the back panel, one for the two end slats and another for the middle slats. Figure 13 shows the lengthening of the back slat end with the Push/Pull Tool. Select one of the middle slats to stretch up to the backsplash; changing one changes them all. This completes fitting of the back panel.

Step 5 The bookcase has no vertical dividers, so the dadoes in the top, the horizontal

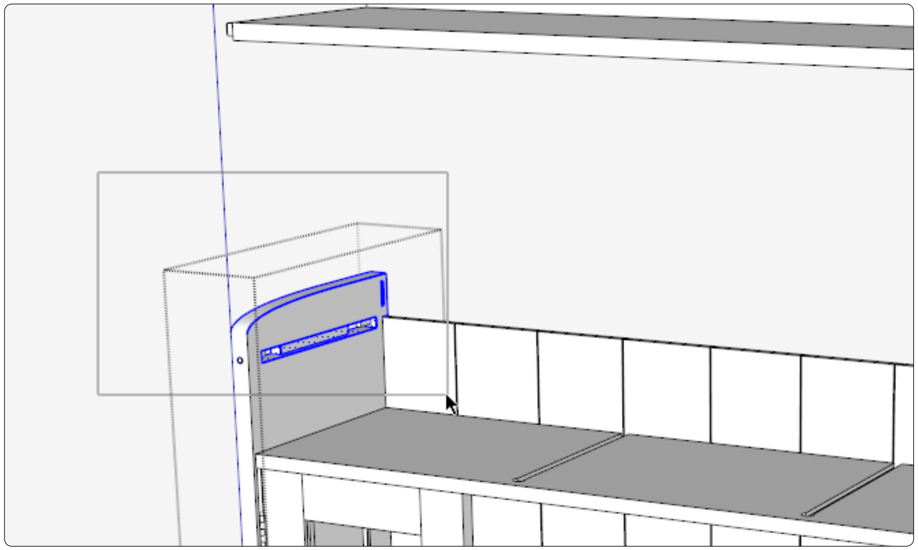


Figure 11. *Draw a selection box around the top of the side, including the mortise.*

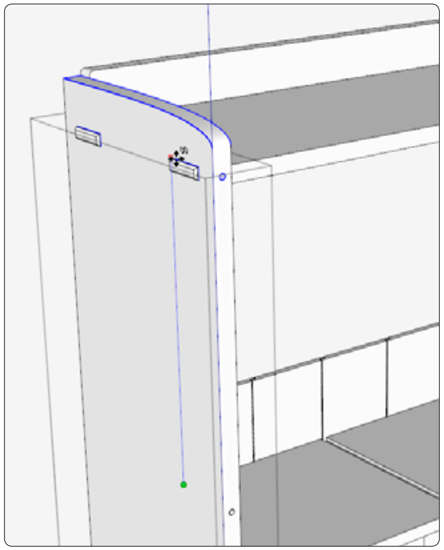


Figure 12. *Pull the top of the side upward until it reaches the tenon on the top.*

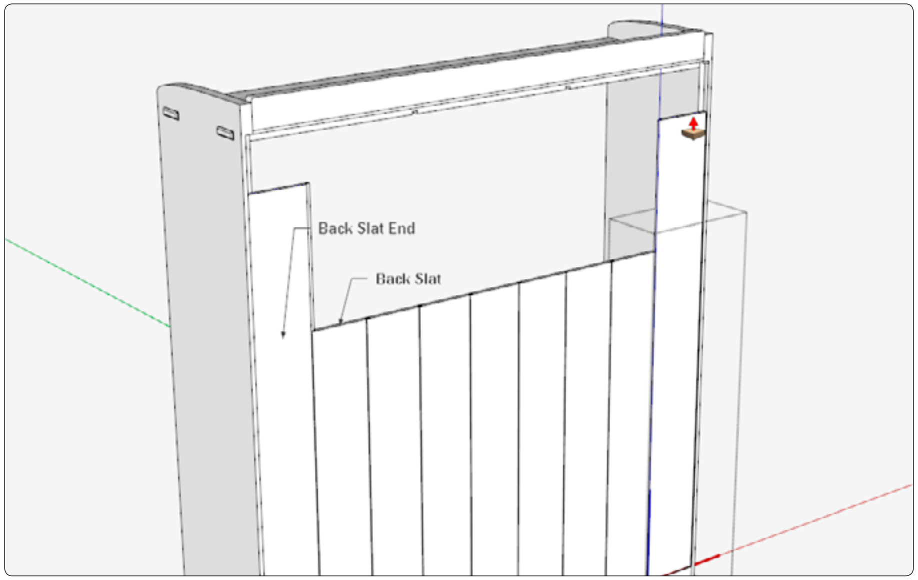


Figure 13. *Raise the back slats up to the rabbet in the backsplash. This requires lengthening two components–the back slat end and the back slat.*

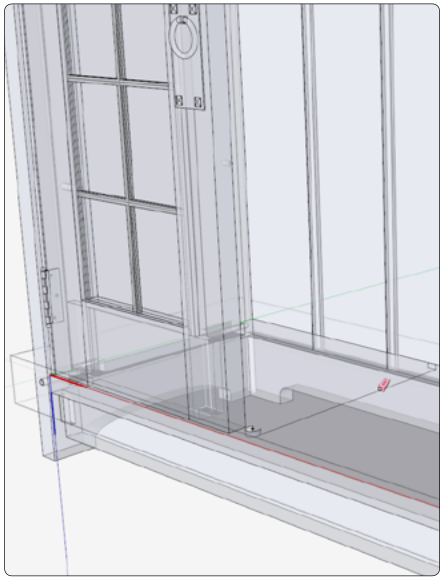


Figure 14. *Remove the dadoes for vertical dividers in the cabinet bottom and top.*

divider, and the bottom components need to be removed. It helps to turn on X-Ray style to delete all the lines forming the dadoes, as shown in Figure 14. The dadoes extend to the back edge of the components, so you need to draw short lines to close them up, otherwise faces of the components will disappear.

Step 6 The bookcase requires a post centered in the front, as shown in Figure 15. It is 2 in. wide and 13/16 in. thick and inset ¼ in. from the front edge of the bottom. See Figure 16. The post will be inset 1/16 in. from the front face of the doors.

The horizontal partition in the original display cabinet will become one of the bookcase shelves. Now, though, it intersects with the front post. Use the Push/Pull Tool to push the front edge of the horizontal partition backward until it clears the post, as shown in Figure 17.

Step 7 Add through tenons to both ends of the front post, as shown in Figure 18. The tenons are ¼ in. thick, ⅞ in. long, and the full width of the post. Open the top and bottom components for editing, trace over the shape of the post tenon, and push out the through mortise, as shown in Figure 19.

Step 8 Open the door stile for editing, select the top of the stile, including the mortise and the recess for the upper hinge. Use the Move/Copy Tool to extend the stile's length until it reaches the underside of the cabinet top. See Figure 20. Although the original door is smaller, the widths of the stiles and rails will work for the larger doors.

Perform the same lengthening procedure

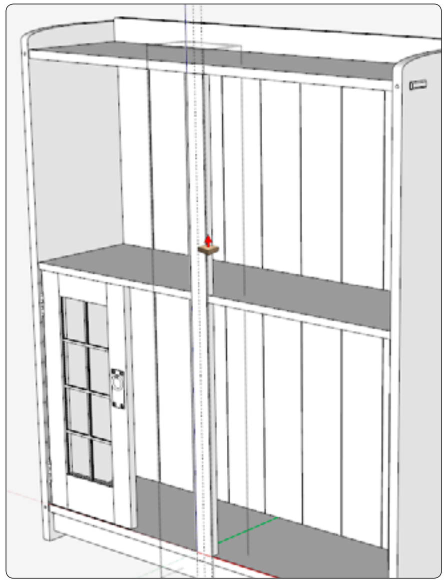


Figure 15. *Draw a post and center it in the front of the bookcase.*

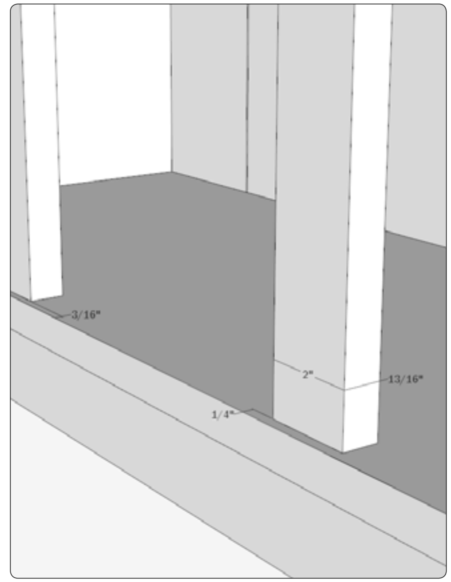


Figure 16. *Inset the front post ¼ in. from the front edge of the cabinet bottom.*

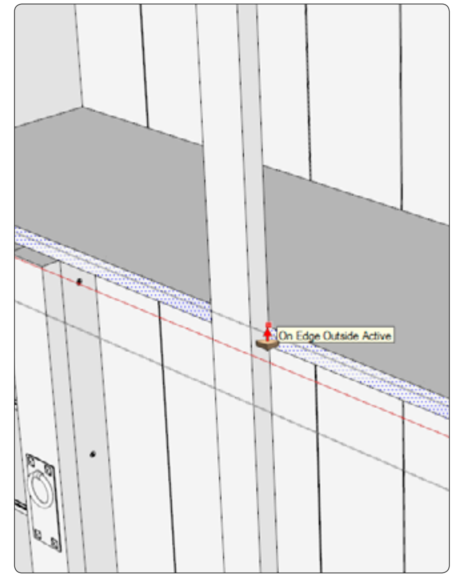


Figure 17. *Push the front edge of the horizontal partition back to clear the post.*

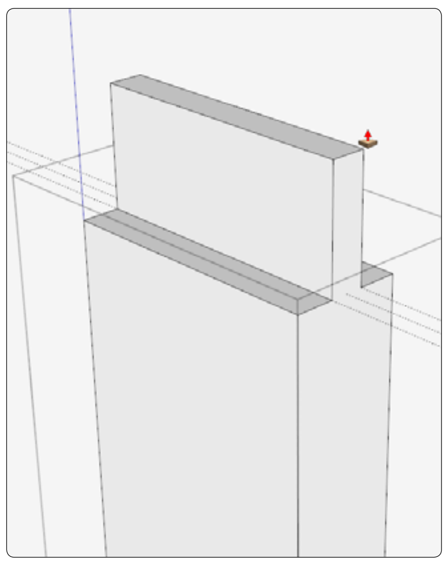


Figure 18. *Add a tenon to each end of the front post.*

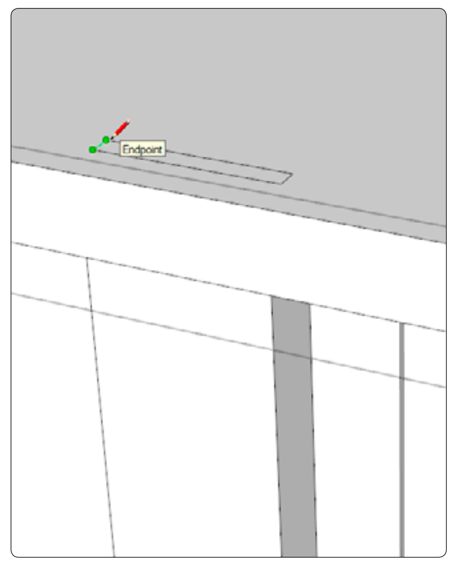


Figure 19. *Add a through mortise to the top and bottom components.*

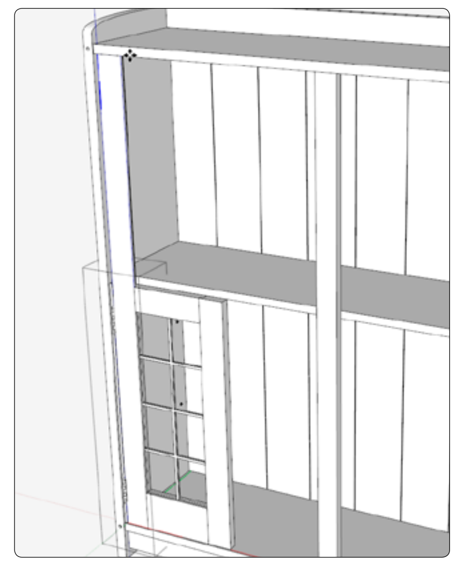


Figure 20. *Extend the door stile up to the bottom edge of the cabinet top.*

to the right door stile and move it to its new position next to the front post, as shown in Figure 21.

Step 9 Move the top door rail up to connect it with the upper right corner of the stile. See Figure 22. Draw a left-to-right selection box around the right half of the rail, as shown in Figure 23, making sure to include the entire tenon within the selection box. With the Move/Copy Tool, click on the right front edge of the shoulder and extend the rail's length until it meets the right stile. See Figure 24. You will adjust the mortise-and-tenon joinery in the next step.

Step 10 The new door will not have a leaded glass frame. Instead, it will have horizontal and vertical muntins 1¼ in. wide and ⅞ in. thick with a ⅜-in. by 7⁄16-in. rabbet in the back. Draw the muntin shape, following the measurements in Figure 25. Changing the muntins entails making the rabbet in the stiles and rails less deep. That, in turn, affects the mortise-and-tenon joints in the stiles and rails.

Copy the stiles and rails and move them away from the cabinet. Move the top rail away from the stile, as shown in Figure 26. Use the Push/Pull Tool to push the back shoulder flush with the front. Orbit around for a view of the stile mortise, as shown in Figure 27. Place a short line across the rabbet at the bottom of the mortise, and pull out the top face to create a stopped rabbet in the back edge of the stiles. Repeat these changes at each joint.

Match the depth of the stile and rail rabbets with that of the muntin shape: 7⁄16 in., as shown in Figure 28.

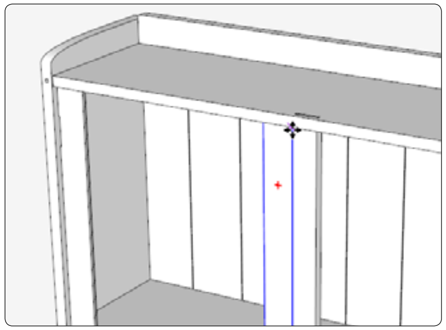


Figure 21. *Lengthen and reposition the right door stile.*

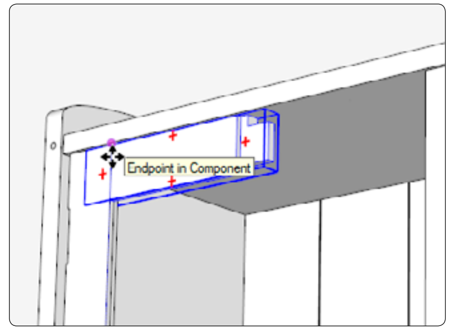


Figure 22. *Move the top rail up to its new location.*

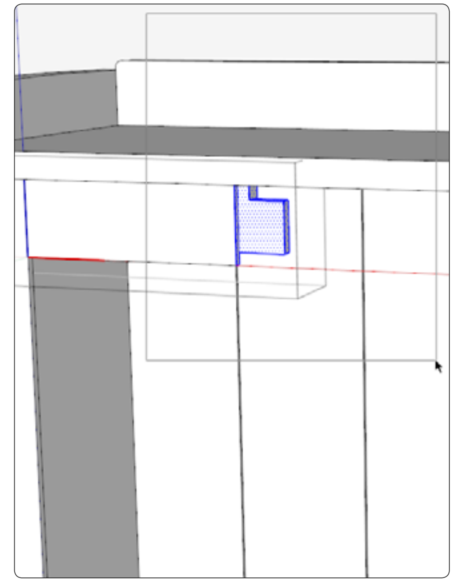


Figure 23. *Draw a left-to-right selection box around the right end of the rail.*

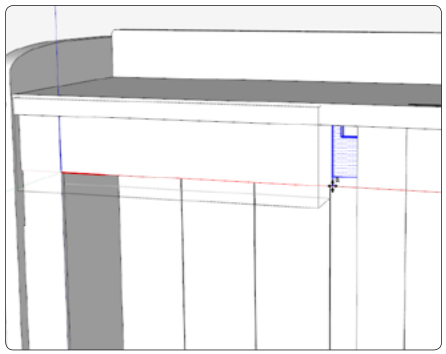


Figure 24. *Extend the length of the rail to the right stile.*

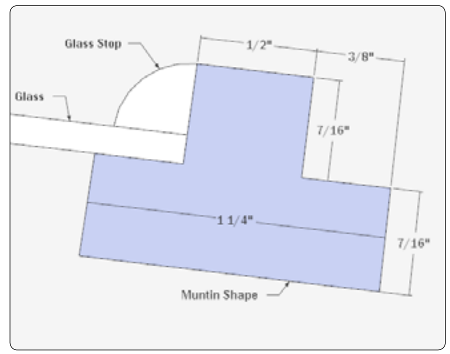


Figure 25. *Make the muntin shape.*

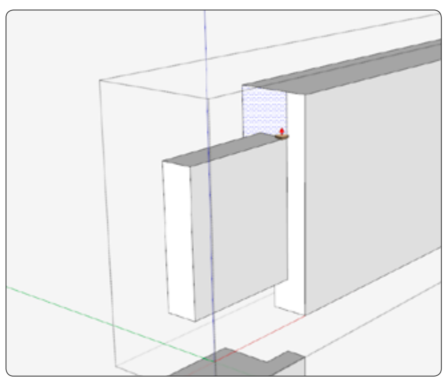


Figure 26. *Make even shoulders on the tenon ends of the rails.*

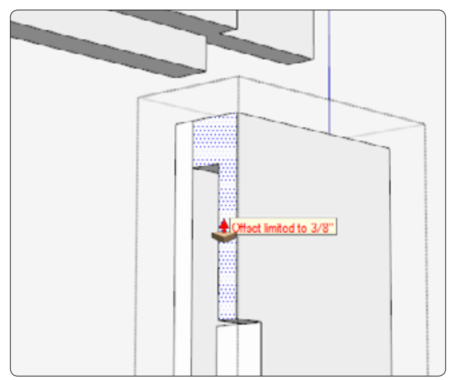


Figure 27. *Pull out the top face, leaving a stopped rabbet in the stiles.*

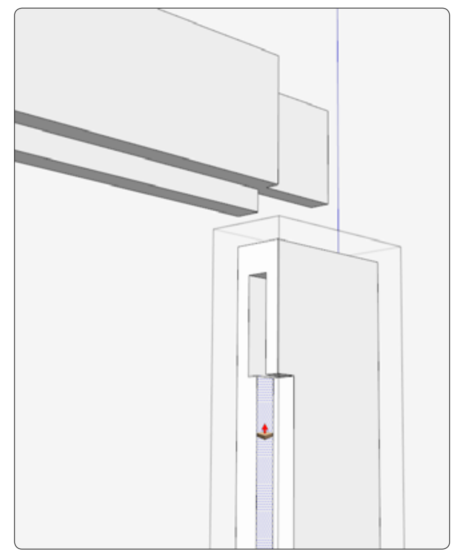


Figure 28. *Decrease the depth of the stile and rail rabbets by 3⁄16 in.*

Step 11 Place a copy of the muntin shape on the underside of the top rail at the midpoint, as shown in Figure 27. Extend the length of the muntin to the top edge of the bottom rail (Figure 28).

Create a ⅞-in.-long tongue on each end of the muntin, as shown in Figure 29. This tongue connects to a socket you will need to create in the back of the rails. See Figure 29.

Step 12 Next, create three equally spaced horizontal muntins in the door opening. To space the muntins, place guidelines ⅝ in. from the inner edges of the rails, then draw a vertical line between those guidelines and divide it into four equal segments. See Figure 30. The divisions in the line locate the midpoint of the muntins. You extend the vertical line beyond the door opening half the width of a muntin; that way, the endpoints and divisions in the line represent the center of a muntin, ensuring that the spaces are equal.

Copy the muntin shape, rotate it, and place it on the stile so that it aligns with one of the division points in the line. Once you place the shape, move the cursor for the Move/Copy Tool over to the divided line to position the shape precisely. Tap the up or down arrow key to constrain the movement on the blue axis. When the cursor reaches a division point, a green dot will appear, as shown in Figure 31. Use the Push/Pull Tool to extend the length of the muntin to the edge of the right stile (Figure 32).

The horizontal and vertical muntin intersect with a lap joint. Open one of the horizontal muntins for editing, place guidelines ⅜ in. from the edges, and trace over the shape, as shown in Figure 33.

Copy the muntin and move it to the front

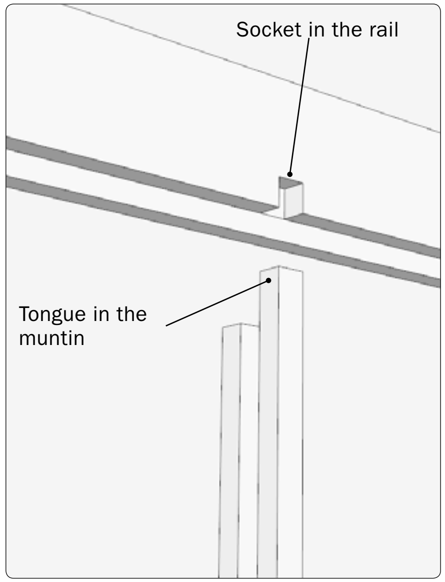


Figure 29. *Create a tongue on the back end of the muntin. Then create rail sockets.*

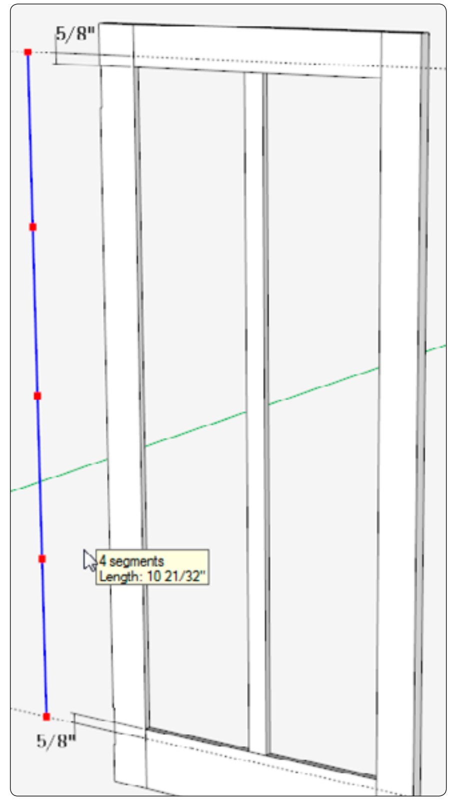


Figure 30. *Place guidelines, then divide a line into four equal segments.*

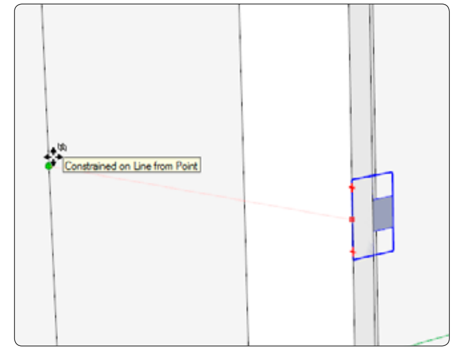


Figure 31. *Place a muntin shape on the stile at a line segment end.*

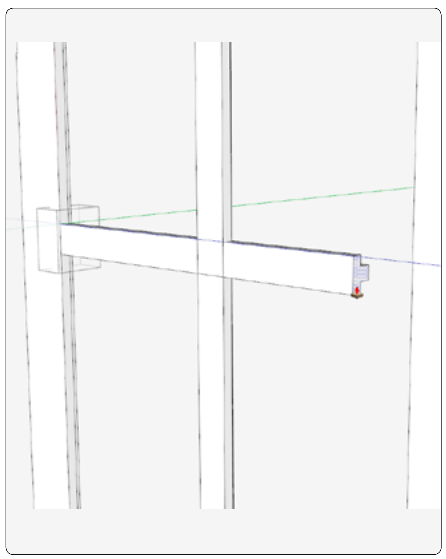


Figure 32. *Extrude the horizontal muntin, stopping at the edge of the right stile.*

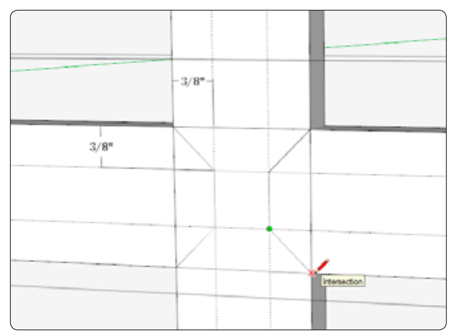


Figure 33. *Place guidelines to help shape the lap joint.*

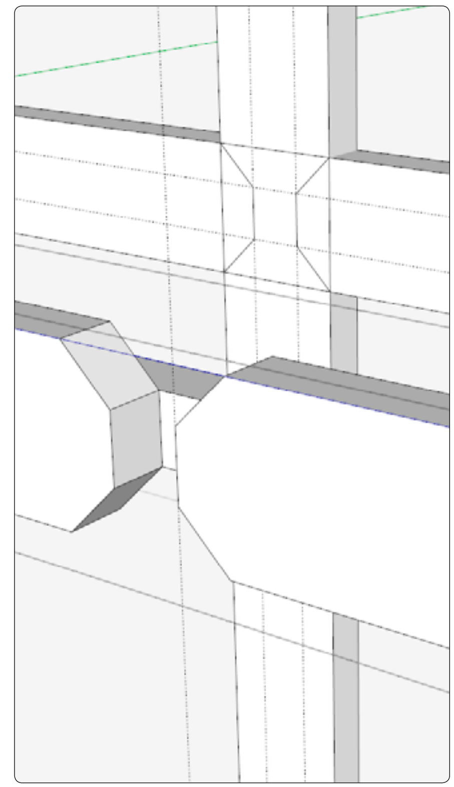


Figure 34. *Remove the waste on the front of the stile.*

of the assembly. Push out the shape to a depth of 7/16 in., as shown in Figure 34.

Step 13 Next, create the matching lap joints in the vertical muntin. Orbit around for a rear view of the lap joint. Open the vertical muntin for editing, and draw two horizontal lines to define the square shown in Figure 35. Use the Push/Pull Tool to push this square toward the front by 7/16 in.

Orbit around for a front view of the joint, as shown in Figure 36. Trace over the angled shape of the horizontal muntin and use the Push/Pull Tool to clear out the highlighted waste shape, again to a depth of 7/16 in. Figure 37 shows the finished lap joint.

Step 14 Orbit around for a rear view again. Make a 7/8-in.-long tongue on each end of the horizontal muntin. See Figure 38. Create the matching socket in the stiles, as shown in Figure 39.

Step 15 Using the divided line created earlier, place copies of the horizontal muntins at the other two division points. Use the midpoint at the end of the horizontal muntin as the copy and move point. See Figure 40.

Orbit around to the rear of the door assembly and make the stile sockets for the tongues on the other horizontal muntins. Create sockets in both stiles.

Orbit around for a front view and finish creating the lap joints where the vertical and horizontal muntins intersect, as you did in Step 13.

Step 16 Place the finished door assembly into the cabinet. Lengthen the hinge strip to the top of the door, as shown in Figure 41.

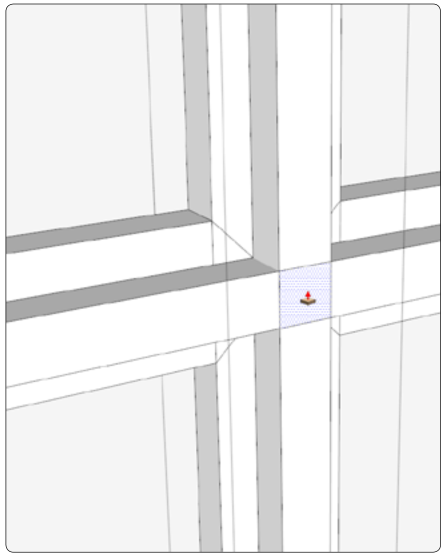


Figure 35. *On the vertical muntin from the rear, push out the square 7/16 in. deep.*

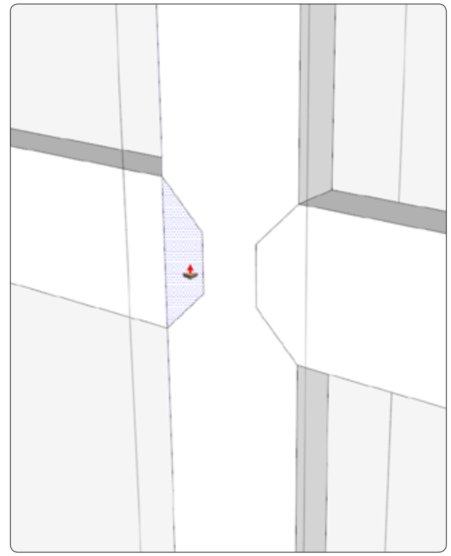


Figure 36. *Trace over the angled shape and remove the waste on the vertical muntin.*

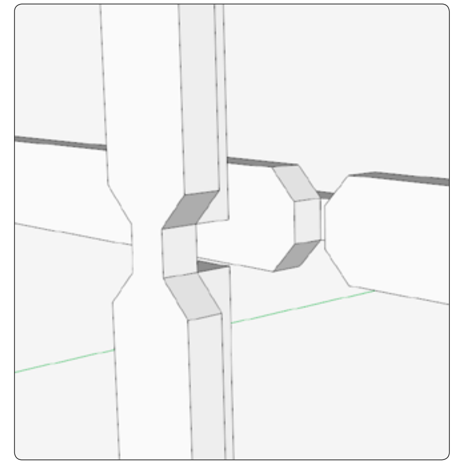


Figure 37. *The finished lap joint.*

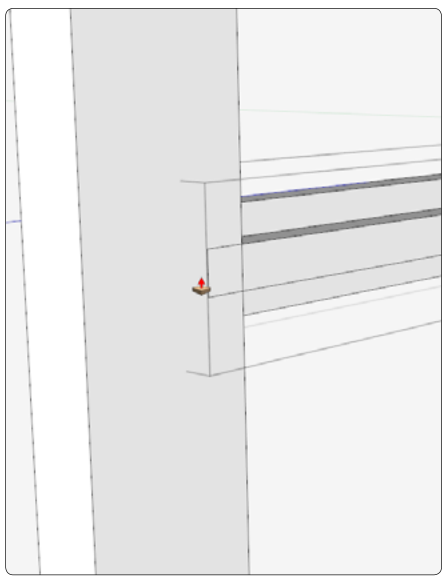


Figure 38. *Extend the tongue on each end of the horizontal muntin so it's 7/8 in. long.*

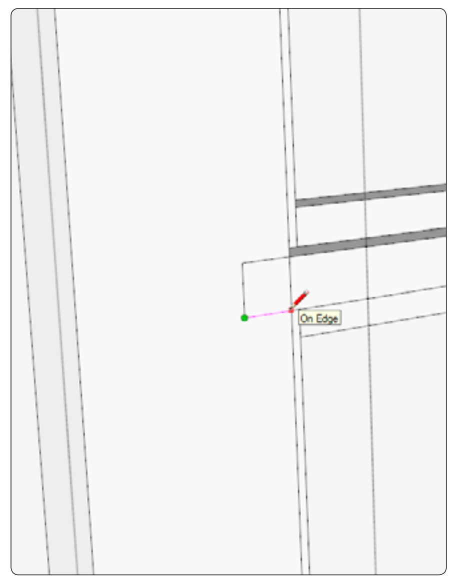


Figure 39. *Make the matching sockets in the stiles.*

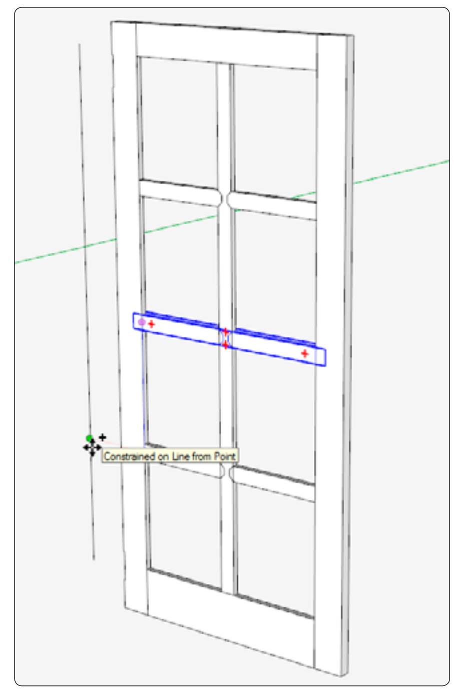


Figure 40. *Copy the horizontal muntin to the other two locations.*

Open the hinge strip for editing and draw a left-to-right selection box around the top of the strip; be sure to include the mortise for the hinge. Use the Move/Copy Tool to extend the length up to the top of the door.

Move the hinge up to its new location. For a door this size, I recommend placing another hinge at the middle of the door. Open the hinge strip for editing and draw a left-to-right selection box around one of the hinge mortises. Copy it and move it along the blue axis to the midpoint of the door. Repeat to add a hinge mortise at the midpoint of the left stile. Copy a hinge and move it into the middle recesses.

Step 17 The original horizontal partition (which is now the middle shelf) must now be repositioned to line up with the middle horizontal muntin. Figure 42 shows the new position, which exposes the original mortise in the side. To shift the location of the mortise, open the side component for editing, turn on X-Ray view, and orbit around for a view like the one shown in Figure 43, from the outside of the side component. Carefully draw a left-to-right selection box around the mortise and move it down to the new position for the middle shelf.

Since the horizontal partition was reduced in width earlier in Step 6, the tenon and associated mortise need to be adjusted in size accordingly.

The other two shelves are adjustable and will require shelf support holes. As you did with the corner cupboard in the previous chapter, make a series of ¼-in.-dia. holes ¼ in. deep, and space them 2 in. apart. To make the adjustable shelves, either modify the center shelf or draw new components.

Step 18 The wedged tenons on the top and bottom components are a typical Stickley feature. The existing tenons must be extended another 1½ in. to accommodate the wedges.

Orbit for a view looking at the top of the cabinet. From the Camera menu, select a Top View and parallel projection. Pan and zoom to a close view of the protruding tenons, as shown in Figure 44. Open the top component for editing and draw a left-to-right selection box around the ends of the tenons; be sure the box includes the chamfer. With the Move/Copy Tool, pull the tenons along the red axis another 1½ in.

Create a wedge shape using the line and arc tools. I placed a flat plane close to the cabinet and drew a freehand shape sized as shown in Figure 45. Make the wedge about ⅝ in. thick. Then make an angled slot ⅝ in. wide in the end of the tenons, which holds the wedges. Chapter 3, Step 23, explains how to make an angled slot. Copy the door hardware from the original cabinet and place it on the new bookcase.

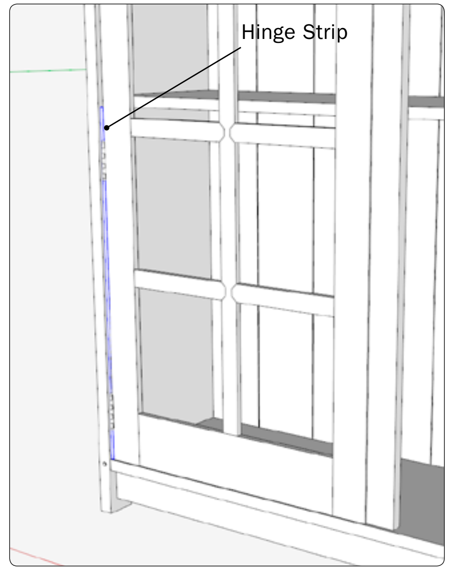


Figure 41. *Resize the hinge strip and move the hinge.*

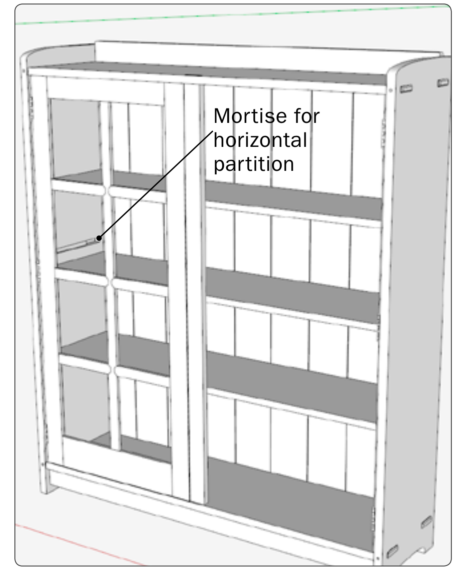


Figure 42. *The exposed mortise in the side needs to be shifted to line up with middle shelf.*

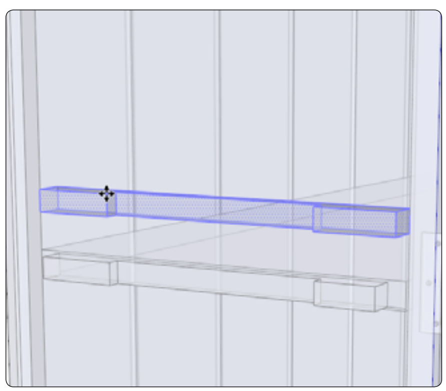


Figure 43. *Select the side mortise and move it down to fit with the middle shelf tenons.*

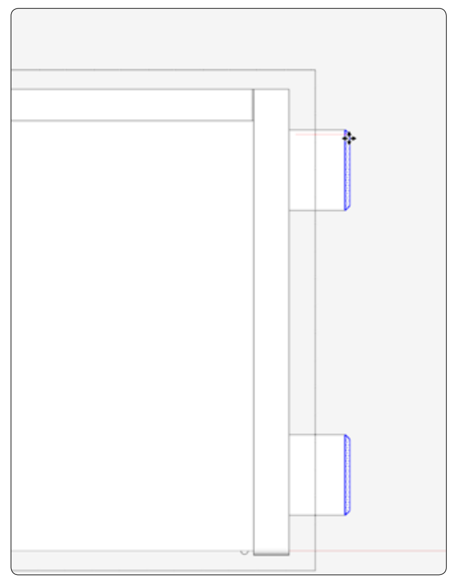


Figure 44. *Lengthen the top and bottom tenons another 1½ in. to for the wedges.*

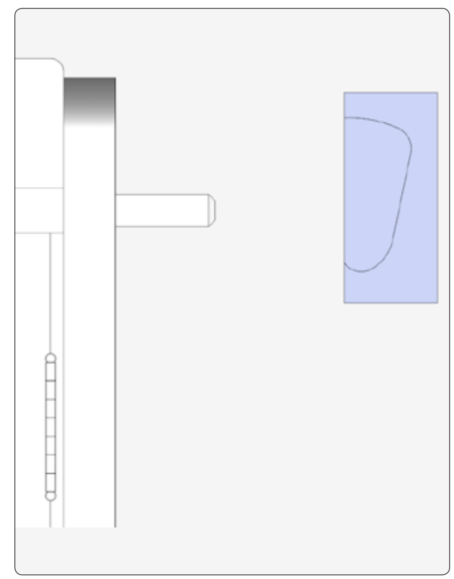


Figure 45. *Create a wedge shape for the top and bottom tenons.*

Status Report

The conversion from an Arts and Crafts cabinet to a Stickley #525 two-door bookcase is complete. Having access to the original cabinet in SketchUp with all its components makes quick work of modeling the new cabinet. There are many similarities between the two pieces. The bookcase doors are quite different in appearance but use the stiles and rails from the display case.

The conversion did not involve use of the Scale Tool. The Move/Copy Tool is most effective for adapting existing components to a new design.

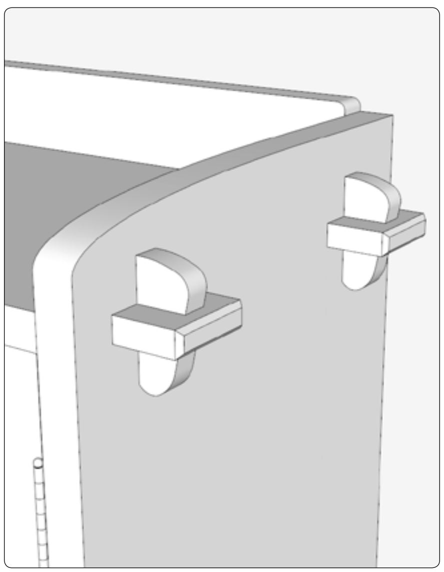


Figure 45. *The wedged tenons.*

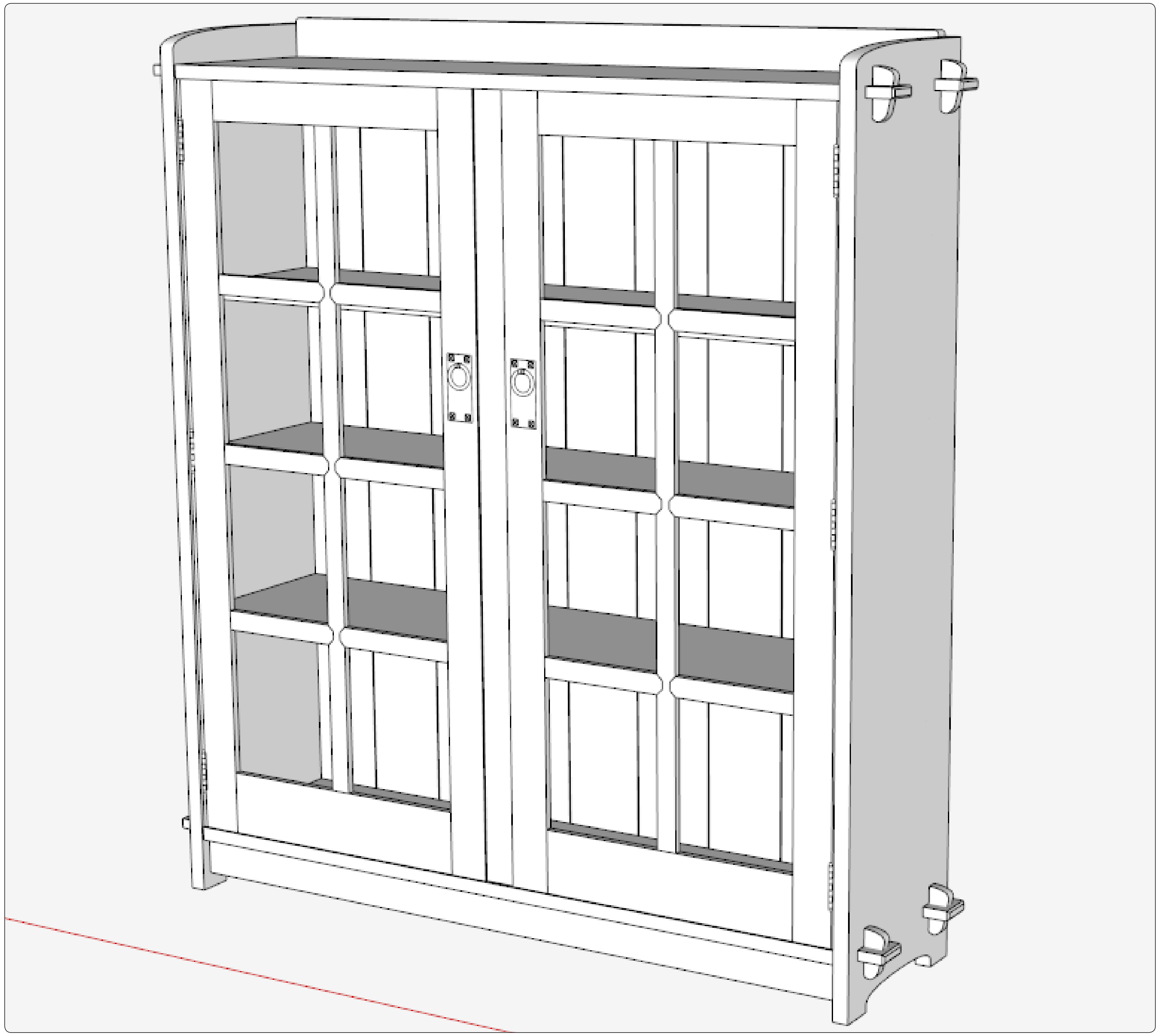


Figure 46. *The completed Stickley #525 two-door bookcase, adapted from the Arts and Crafts display case.*

Convert the Magazine Cabinet to a Shaker Press Cupboard

The magazine cabinet we built in Chapter 3 can be adapted to larger applications, including those without wall mounting. In this section, we'll convert the original wall-mounted cabinet to a much larger storage cupboard resting on a stand.

My inspiration for the conversion was a photo in *The Book of Shaker Furniture*, by John Kassay. He showed an original Shaker press cupboard made in Pleasant Hill, Kentucky. The piece consisted of a base with a drawer and a two-door shelved cupboard on top. Its original purpose in the Shaker village was to store neatly folded stacks of household linens, such as pillowcases, sheets, and towels, after they had been laundered and ironed. A more contemporary use could be a bookcase and storage for home files, papers, stationery, envelopes, recipes, and the like.

Figure 47 shows the "before and after" cabinets side by side. The new cabinet is slightly more than 1½ times the width and height of the original. The depth does not change proportionately but increases by more than 2 in.

Figures 48 and 49 strip down the two cases to show the relative sizes and dimensions of the basic carcases.

To minimize the conversion work, I'll make use of existing joinery, including the dovetails and wedged mortise and tenons. I think these joinery choices are good ones for the larger cupboard. I have modified the way the shelves join the carcase sides because of the larger size of the Shaker cupboard.

Step 19 Create a boundary enclosure, as shown in Figure 49, which will help you re-

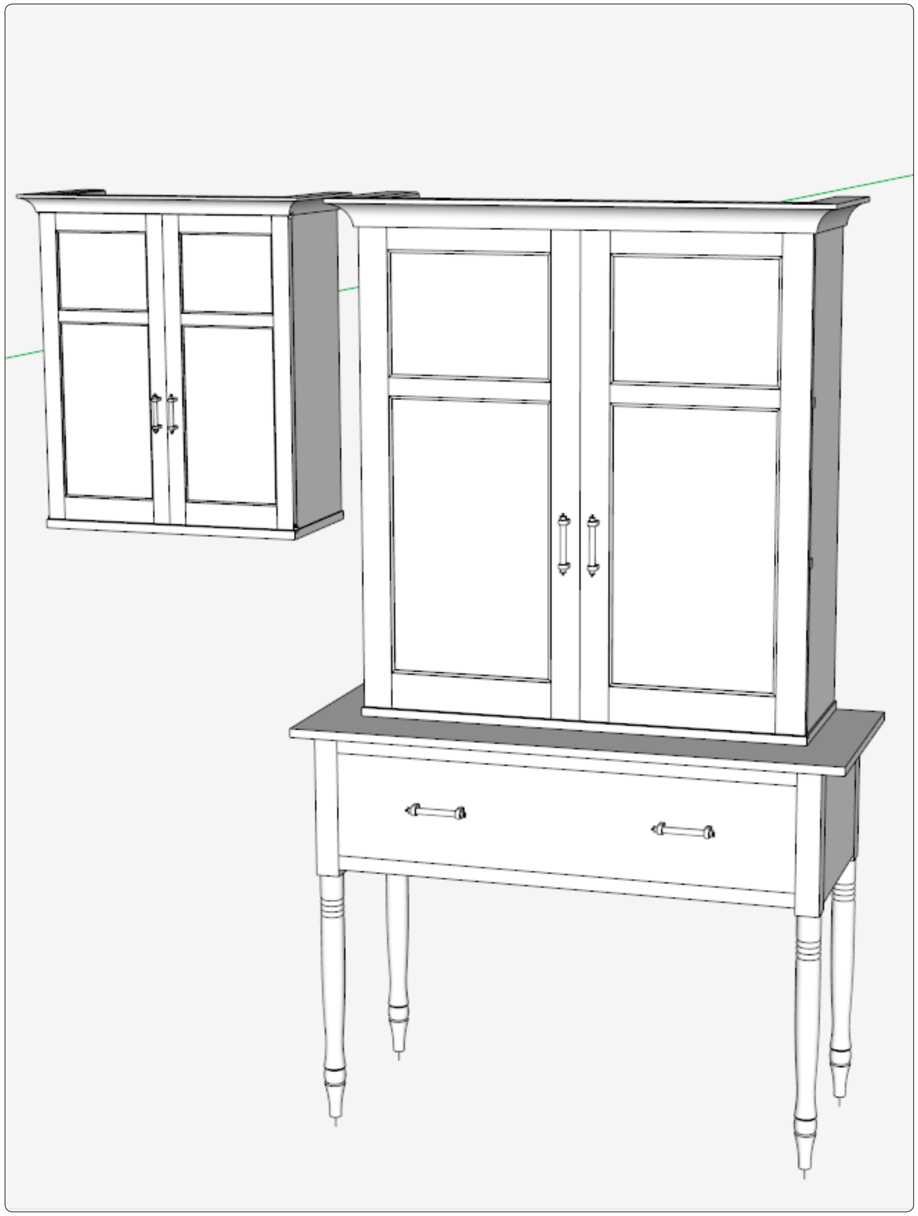


Figure 47. *The original wall-mounted cabinet is the basis for a larger Shaker-style cupboard on stand.*

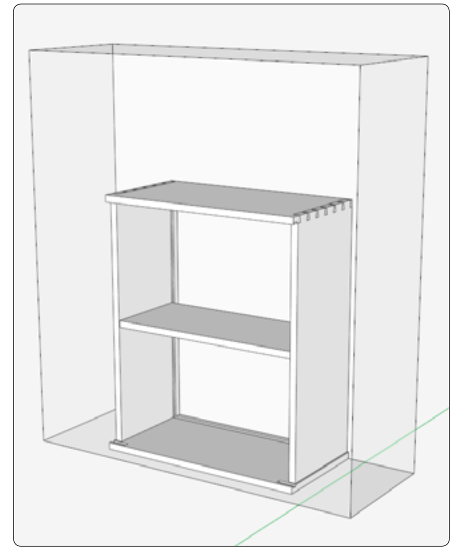


Figure 48. *The boundary of the larger cabinet surrounding the original*

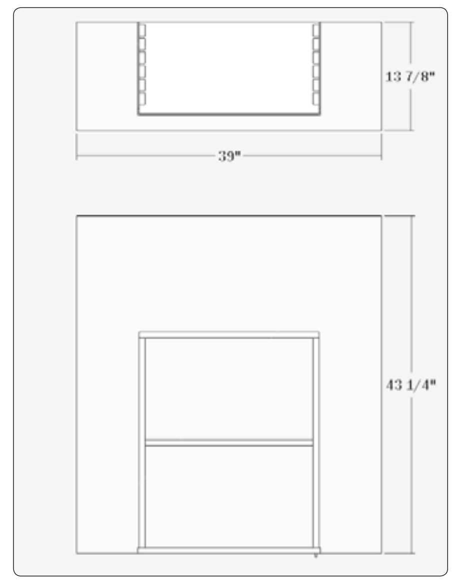


Figure 49. *A front and top view of the comparative sizes, with overall dimensions.*

size the magazine cupboard components. Use the dimensions in that figure. You can delete the faces of the boundary box so you can easily grab the magazine-cupboard components inside. The leftover edges are sufficient for limiting how much you stretch components.

I originally "painted" the boundary box with less-opaque materials, but ended up deleting most of the faces to make it easier to access the model inside.

Place the original cabinet in the enclosure, centered left to right and with its back edge flush with the back of the enclosure. Delete the doors, back panel, French cleat, hardware, and crown molding.

As shown in Figure 50, draw a left-to-right selection box around the top joinery of the side component. Then use the Move/Copy Tool to raise the height of the side up to the boundary box.

When you make these extensions and movements, be sure to tap the appropriate arrow keys to constrain the movement to a particular axis. Once you do that, you can move the cursor away from the component to click on reference graphics to precisely stop movements.

Step 20 Select the left end of the bottom component, as shown in Figure 51, and move it outward to the edge of the bounding box. Lengthen the right end of the bottom component, as shown in Figure 52.

Select a Top camera view and parallel projection. Draw a selection box around the front end of the bottom component, including the recess for the hinges. Use the Move/Copy Tool to extend the front edge out to the bounding box.

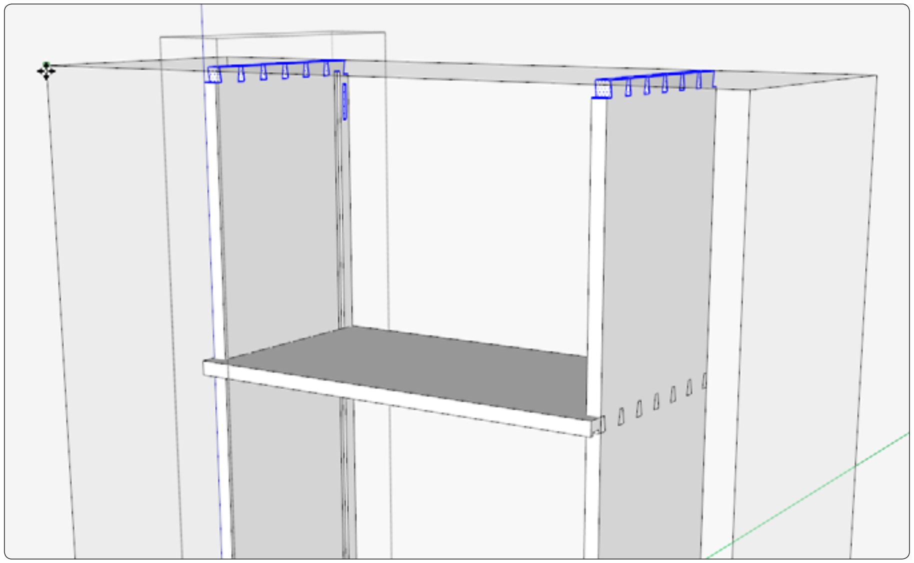


Figure 50. *Select the upper end of the side component, including the dovetail joinery, and use the Move/Copy Tool to raise the height of the side to the bounding box.*

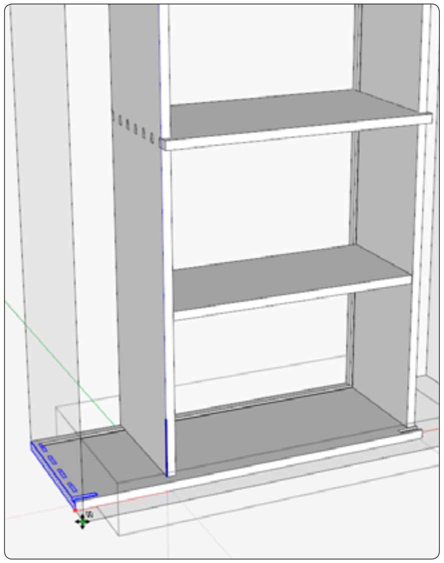


Figure 51. *Select the left end of the bottom and stretch it to the bounding box.*

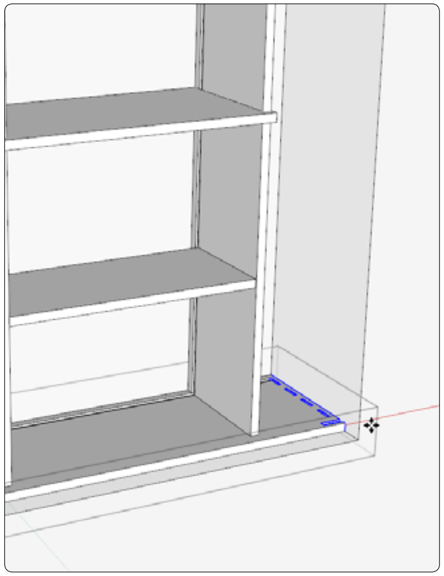


Figure 52. *Lengthen the right end of the bottom component to the bounding box.*

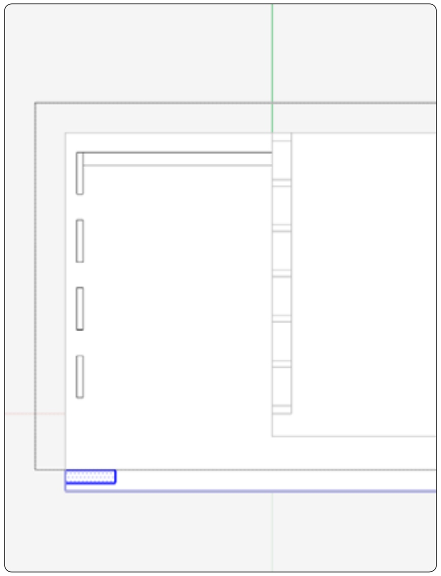


Figure 53. *Select the front end of the bottom and pull it out to the bounding box.*

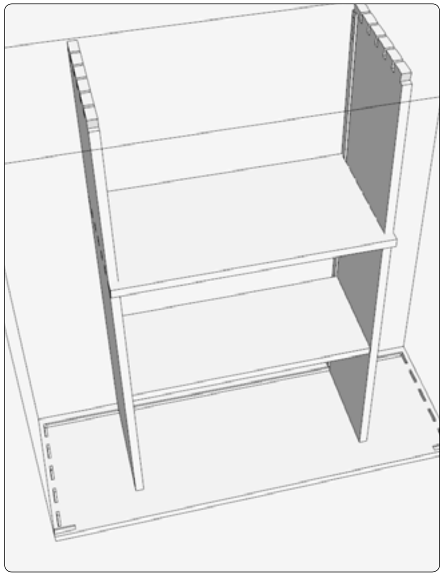


Figure 54. *Current status, with side and bottom components lengthened.*

Step 21 Making the bottom component wider creates room for another mortise. While still in the top view and parallel projection, copy a mortise and space it 1 in. from its neighbor. Do this on both ends.

Step 22 With the Move/Copy Tool, click on the end of the front tenon on the side component. Orbit for a bottom view of the cabinet, as shown in Figure 56. Move the side component until it connects with the corner of the mortise in the bottom component. Repeat the move with the right side component.

Step 23 Place a guideline 1 in. back from the edge of the bottom. See Figure 57. Open the side for editing and pull its front edge out to the guideline.

Set up a right side view of the bottom component. Set the Camera to Parallel Projection and the style to X-Ray, as shown in Figure 58. The new mortise that you added to the bottom in Step 3 is too wide and too close to the front edge of the side. Select the left end of the mortise and move it toward the rear of the case by ½ in. This mortise will be ½ in. narrower than the others.

Open the side for editing and copy a tenon to the new mortise location. Connect it precisely to the front edge of the mortise. Then shorten the right end of the tenon, as shown in Figure 59. Draw a left-to-right selection box around the right side of the tenon, then use the Move/Copy Tool to shrink it to fit exactly in the smaller mortise.

Step 24 Move the top component up to the dovetail joints in the top of the side, as shown in Figure 60. Select the right end of

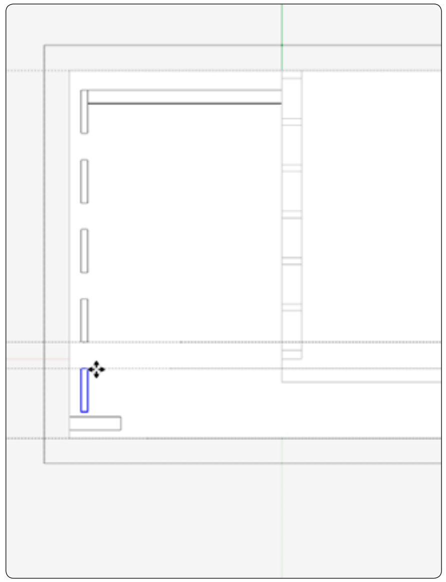


Figure 55. *Copy a mortise into the front of the bottom component.*

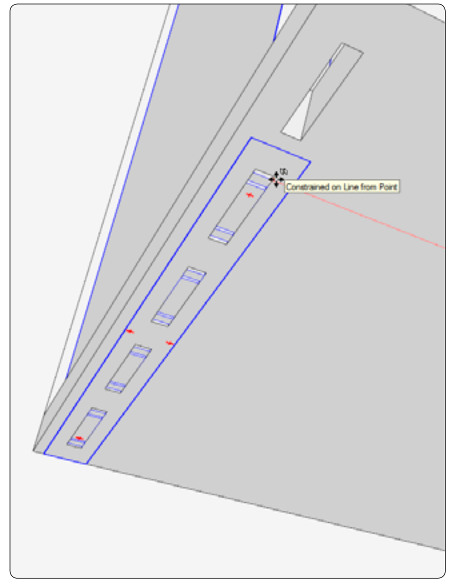


Figure 56. *Move the side component to the mortises on the end of the bottom.*

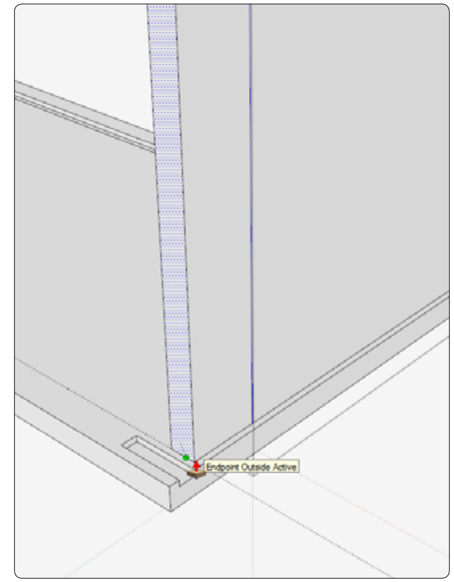


Figure 57. *Increase the side's width to 1 in. from the front edge of the bottom.*

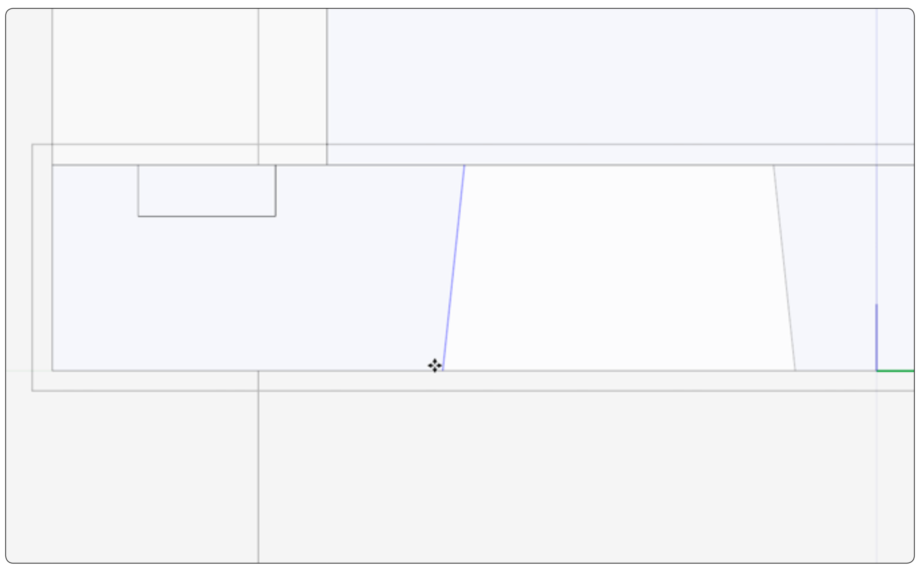


Figure 58. *Decrease the width of the front mortise in the bottom component by ½ in.*

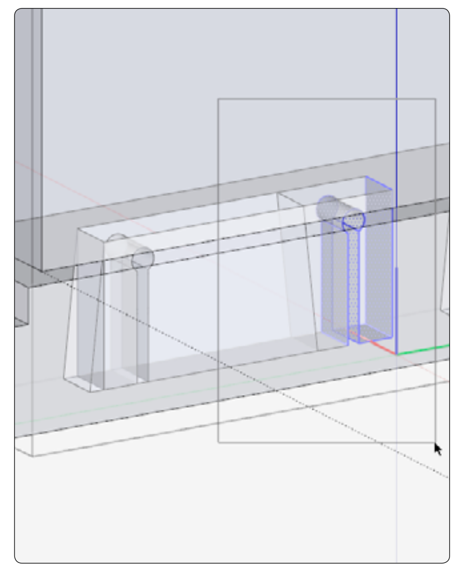


Figure 59. *Copy a tenon on the side, then shorten it with the Move/Copy Tool.*

the top component and stretch it to connect with the dovetails on the right side. See Figure 61. The top must be widened to fit the new depth of the cabinet. Change to a top view with X-Ray style, as shown in Figure 62. Draw a left-to-right selection box around the front edge of the top, including the recesses for the hinge. Use the Move/Copy Tool to extend the width of the top; use the front edge of the bottom as a reference for ending the move.

Step 25 The increased width of the top requires another dovetail. Switch to a side view with parallel projection, as shown in Figure 63. Open the top for editing and select a dovetail. Because you are in a standard side view and in parallel projection, the selection will also pick up the matching dovetail at the opposite end. Copy the dovetail and move it to the open space. I set a guidepoint to ensure that the pin will be the same size as the others.

Move the top away from the side component as shown in Figure 64. Use the Eraser Tool to delete the edges and open up the dovetail. Return the top to the carcase, as shown in Figure 65.

Open the side for editing and use the Line Tool to close the side face of the dovetail. Then use the Push/Pull Tool to fill the entire dovetail opening. See Figure 66. Delete any extra lines in the dovetails, as shown in Figure 67.

Step 26 The rear of the magazine cabinet has ½-in.-wide grooves for the back panel, inset to accommodate the French cleat. The new cabinet will be rabbeted for its back, so the grooves must go. Copy the bottom com-

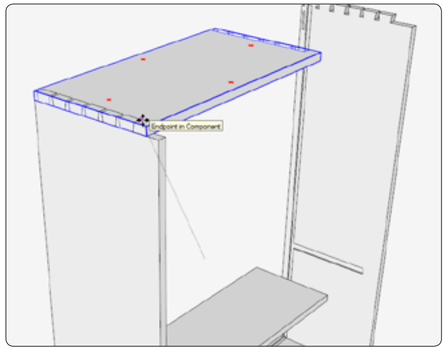


Figure 60. *Raise the top to connect it with the dovetail joints.*

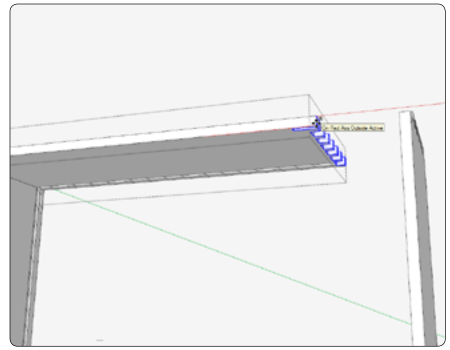


Figure 61. *Stretch the right end of the top to connect it with the side dovetails.*

Figure 62. *Extend the front edge of the top to the same width as the bottom component.*

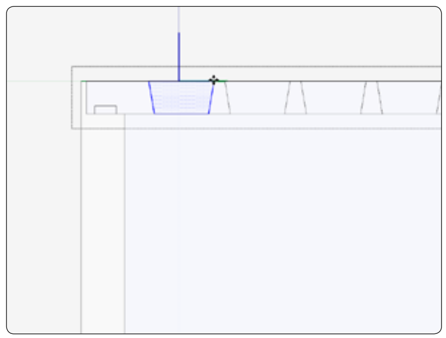


Figure 63. *Copy a dovetail joint to the open space at the front of the top.*

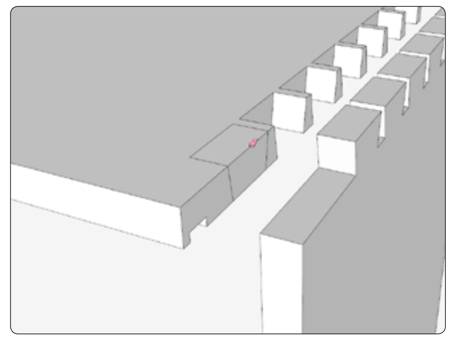


Figure 64. *Move the top component and delete the extra lines to open the dovetail.*

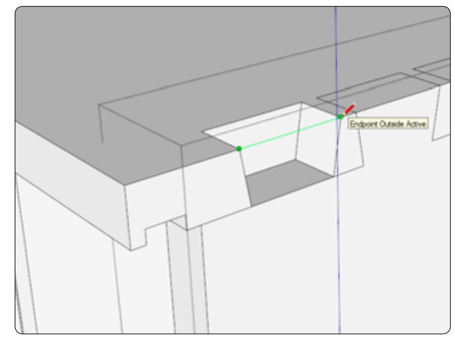


Figure 65. *Open the side for editing and create the side face of the dovetail.*

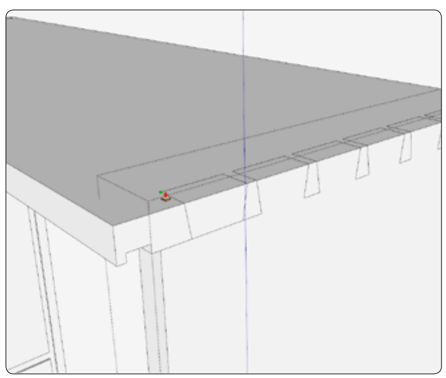


Figure 66. *Use the Push/Pull Tool to fill in the dovetail gap.*

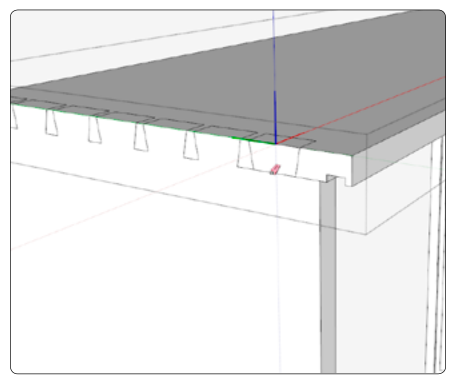


Figure 67. *Delete any extra lines on the dovetails at either end of the cabinet.*

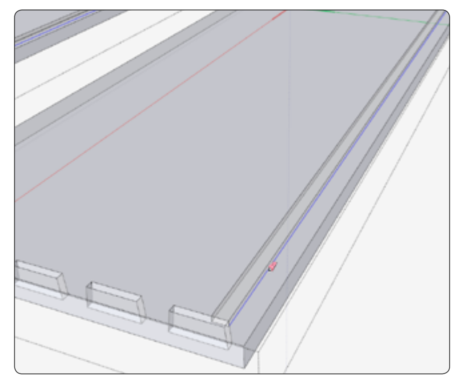


Figure 68. *Delete the grooves in the back of the carcase.*

ponent and move it away from the assembly. Delete the groove, as shown in Figure 68. Use the Line Tool to close the ends of the grooves before deleting their edges. Otherwise, you will lose the entire top face of the bottom component. Shift to X-Ray style so you can delete the lower hidden lines of the groove. Eliminate the grooves in the top and side components.

Step 27 Delete the mortise in the inside face of the side that connected the no-longer-needed French cleat. Use the Eraser Tool in X-Ray style to delete all the mortise edges. See Figure 69.

Step 28 Remove the dovetail pin at the back corner of the top and side. See Figure 70. Set up a side view, open the side component for editing, draw a left-to-right selection box around the pin, and then press the delete key. Open the top component for editing and remove the dovetail pin with the Push/Pull Tool, as shown in Figure 71.

Step 29 To create a ½-in. by ½-in. rabbet in the back edge of the carcase, place guidelines ½-in. from the inside edge of the components, as shown in Figure 72. Draw over the guidelines and use the Push/Pull Tool to create the rabbets in each component. See Figure 73.

Step 30 Move a copy of the original back panel into the rabbets you just created. See Figure 74. With an opening this size, use two back panels, side by side. Convert the original back panel into one that fills half of the opening.

Open the back panel stile for editing and

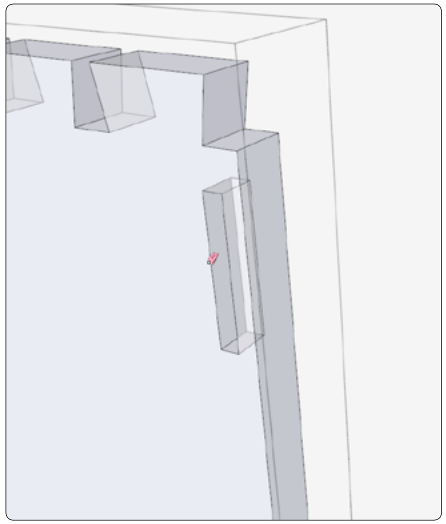


Figure 69. *Delete the mortise for the French cleat in the inside face of the side.*

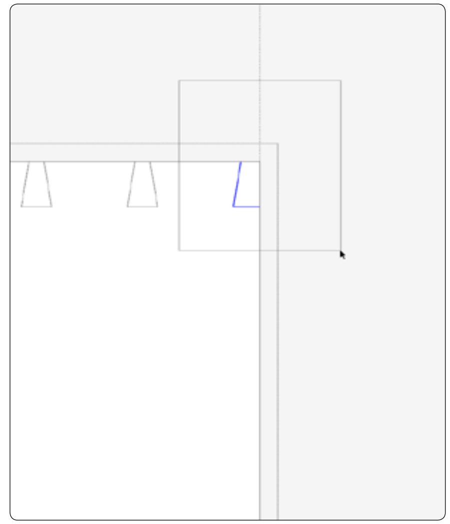


Figure 70. *Delete the back edge dovetail in the side component.*

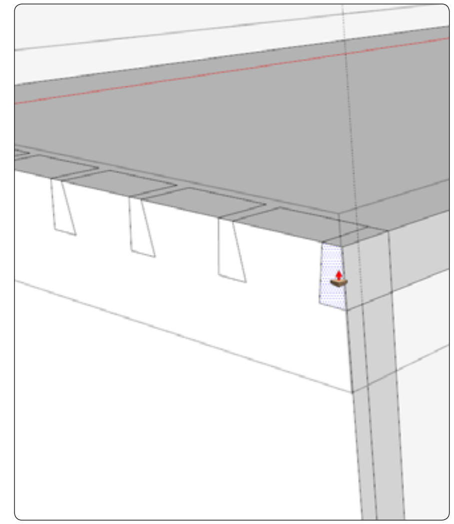


Figure 71. *Delete the back edge dovetail in the top component.*

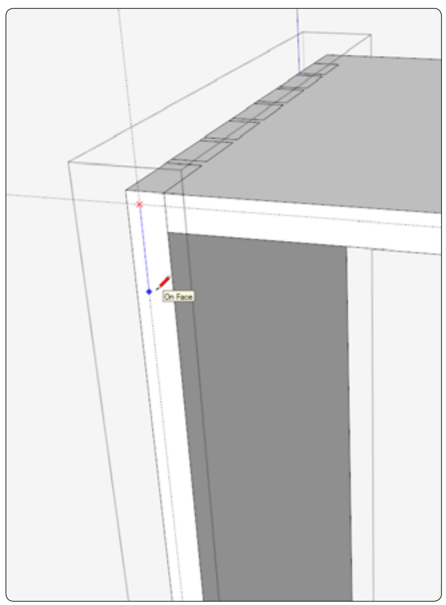


Figure 72. *Draw guidelines for the rabbet that will hold the back panel.*

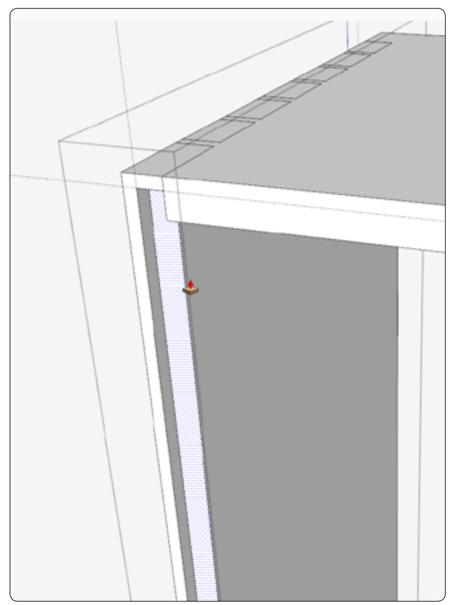


Figure 73. *Use the Push/Pull Tool to make the rabbet in each carcase component.*

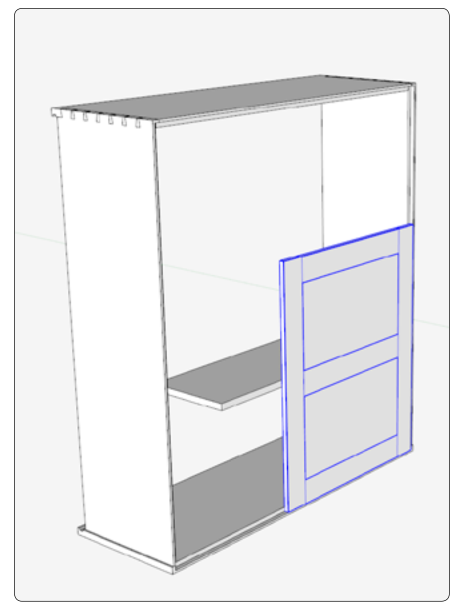


Figure 74. *Move a copy of the original back panel into the back rabbet.*

select the top, including the mortise. Use the Move/Copy Tool to extend the length of the stile up to the rabbet in the top component. See Figure 75. Move the top rail up to meet the stiles (Figure 76). Copy the middle rail and move it up into the open space above the panel (Figure 77).

Using a second middle rail keeps the floating door panels at an appropriate size. I positioned the two middle rails so that the top and bottom floating door panels are the same size and the center floating panel slightly larger. However, you could space the rails to create three identical panels.

Once you have positioned the rails, open a stile for editing, select the mortise, and move it to its new location. Then copy the mortise and move it up to meet the tenon on the other rail.

Copy the bottom floating panel and move it up to the top of the back. See Figure 78. The floating panels have a 1⁄16-in. gap for expansion around the shoulder of the raised panel. To achieve that gap, grab the top edge of the panel, tap the up or down arrow key, and stop moving the panel when it connects with the lower edge of the top rail. At this point there is no gap at all. Click on the top edge of the floating panel, tap the up or down arrow key, and begin moving the panel downward. Type 1⁄16 and press enter. This produces a precise gap.

Repeat with another copy of the floating panel to create the center panel. See Figure 79.

The back panel is wider than half the width of the opening. Use the Move/Copy Tool to grab the end of the left stile at its left upper corner, then move it to the right until it reaches the midpoint of the back edge of

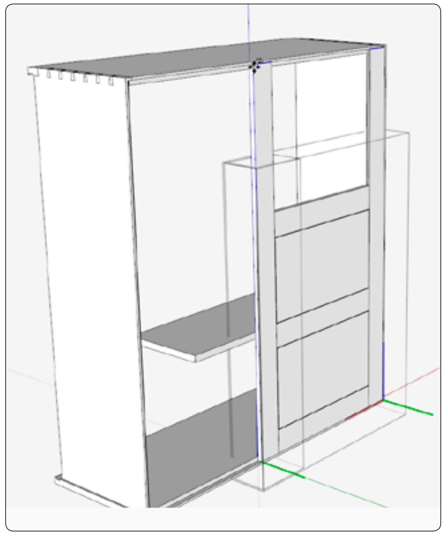


Figure 75. *Lengthen the back panel stile.*

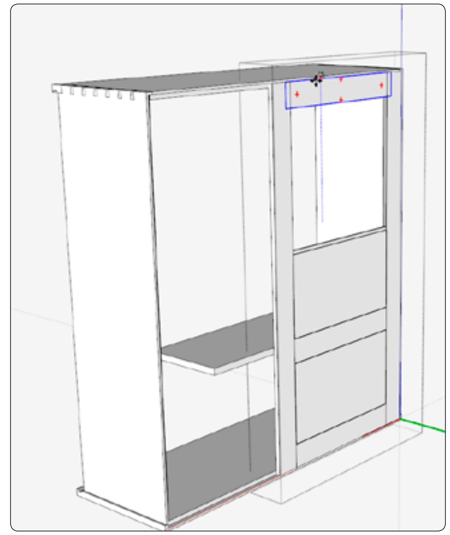


Figure 76. *Move the top rail into its new position.*

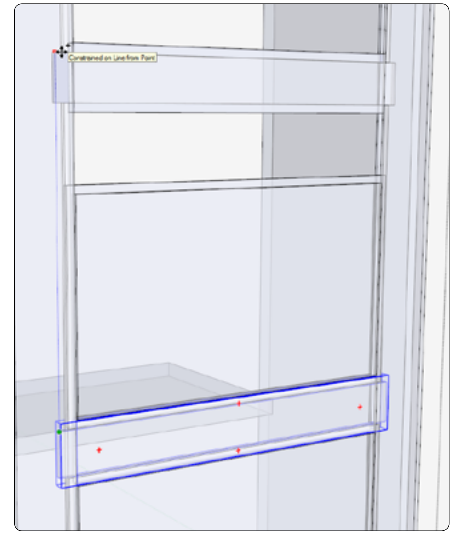


Figure 77. *Copy the middle rail and position it in the open space above the floating panel.*

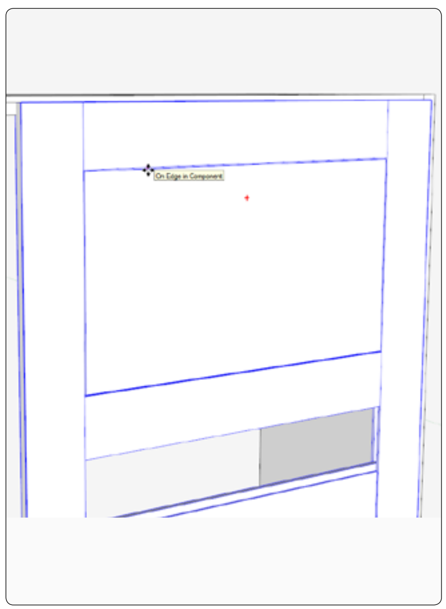


Figure 78. *Copy the lower floating panel and move it to its new position at the top.*

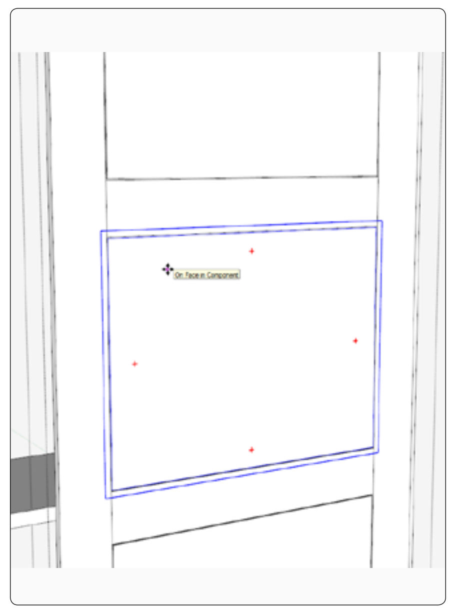


Figure 79. *Resize the panel to properly fit the opening.*

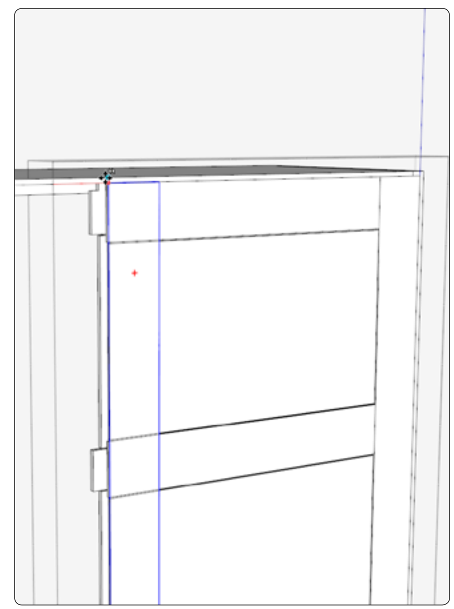


Figure 80. *Shorten the rails to fit.*

the top component. See Figure 80. Now, of course, the rails and floating panels are too wide. Select the ends of these components and use the Move/Copy Tool to shorten them to fit.

When you have finished this back panel assembly, copy it and move it into the remaining space, as shown in Figure 81.

I simply butted the two halves in the middle. Alternatively, you could create a shiplap joint, which would require a slight increase in the width of each panel assembly.

Step 31 This cabinet is tall enough for more than one shelf. I'll show it with two shelves, but it could hold at least three. The original cabinet used ¾-in.-thick stock for the shelves, but I recommend increasing that to ⅞ in. for the larger cabinet. The added thickness should avoid unacceptable amounts of sagging.

Decide on the shelf spacing and place guidelines for their position on the side.

The original shelf must be widened, so move it to butt against the back corner, as shown in Figure 82. Pull out the front edge so it is flush with the front edge of the side.

Move the shelf to the side, so it penetrates the side component by ¼ in. That is the depth of the dado needed to hold the shelf. See Figure 83. Orbit for a view of the other end of the shelf. Extend its length to butt against the other side. Extend the shelf another ¼ in. (Figure 84).

Open the side for editing and trace around the intersection of the shelf with the inner face of the side (Figure 85). These lines outline the dado. Copy the side and move it away from the assembly. Use the Push/Pull Tool to create the dado. See Figure 86.

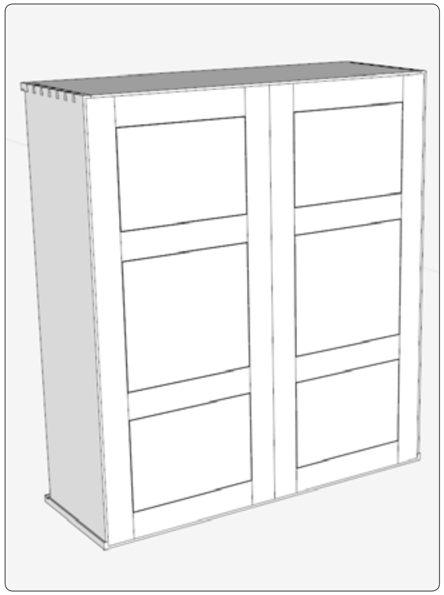


Figure 81. *The finished cabinet back.*

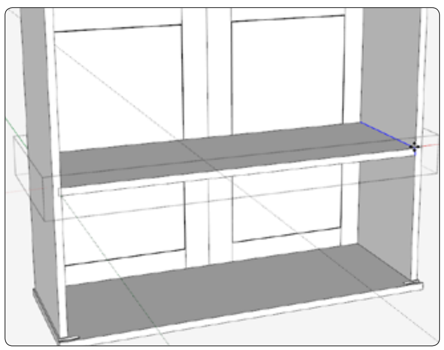


Figure 84. *Extend the length of the shelf to the opposite side.*

Step 32 For cabinets this size, I use half-dovetail joints to connect the shelves to the cabinet sides. It is a typical detail on 18th century and Shaker furniture. I use a through dovetail, which shows on the outer

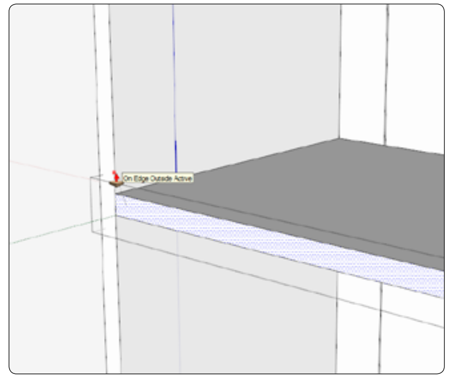


Figure 82. *Increase the width of the shelf.*

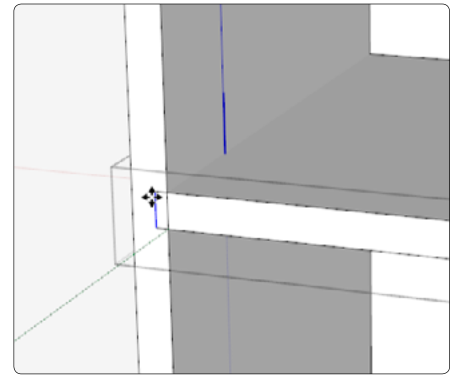


Figure 83. *Move the shelf so that it penetrates the side by ¼ in.*

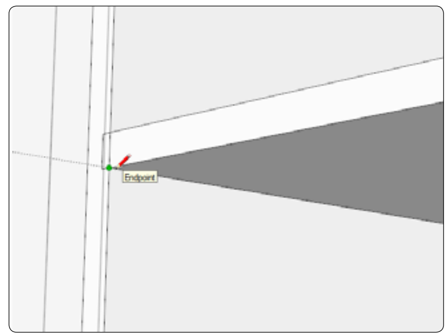


Figure 85. *Outline the dado on the side.*

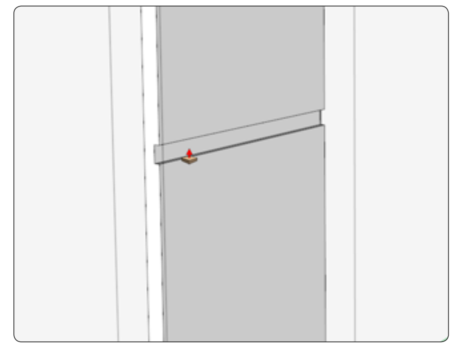


Figure 86. *Use the Push/Pull Tool to make a ¼-in.-deep dado.*

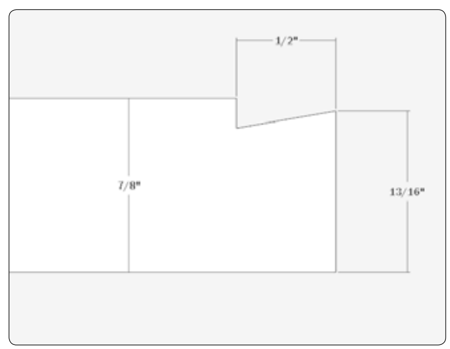


Figure 87. *The dimensions for the dovetail.*

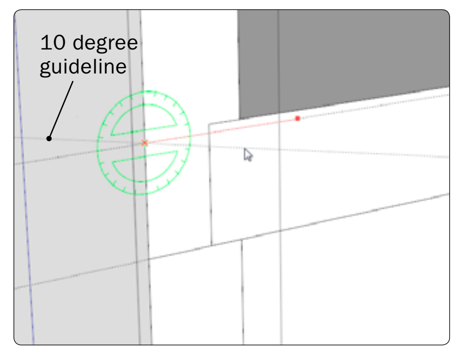


Figure 88. *Lay out the dovetail and the 10-degree angle on the shelf.*

face of the sides. The joint can also be made as a blind dovetail.

The dovetail extends only 1 in. back from the front edge of the shelf and provides a strong tie across the front and along the height of the cabinet.

The first step is to create the shape of the half-dovetail. Figure 87 gives its dimensions. Be sure the shelf is inserted in the dado (Figure 88).

Open the shelf for editing, orbit for a front view, and place a guideline 1/16 in. down from the top edge of the shelf. Use the Protractor Tool to place a 10-degree angled guideline connected to the intersection of this guideline with the outside edge of the side.

Figure 88 shows the intersection. Trace over the angled guideline with the Line Tool (Figure 89) and trace lines around the shape of the dovetail.

The images on this page illustrate each step in creating the dovetail. It involves several back-and-forth component openings and closings.

Push the dovetail shape back 1 in. from the front edge of the shelf (Figures 90 and 91). Open the side for editing and trace over the dovetail shape. Figure 90 shows the face of the dovetail highlighted and Figure 92 shows the Line Tool making that traceover on the side. With the Push/Pull Tool, push back the face of the dovetail by 1 in.

Close the side and pull the shelf away from the carcase slightly, as shown in Figure 93. Open the shelf for editing and delete the extra line on the front edge.

Draw a left-to-right selection box around the dovetail joint (Figure 94), copy the joint,

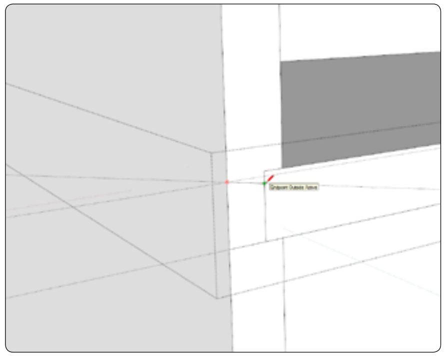


Figure 89. *Trace a line along the angled line and other edges of the dovetail.*

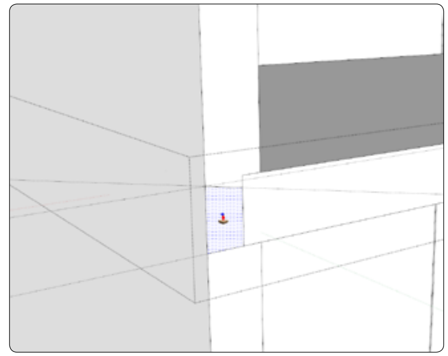


Figure 90. *The dovetail shape is highlighted.*

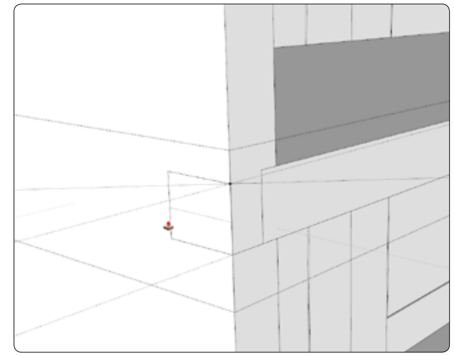


Figure 91. *Push the dovetail shape back 1 in.*

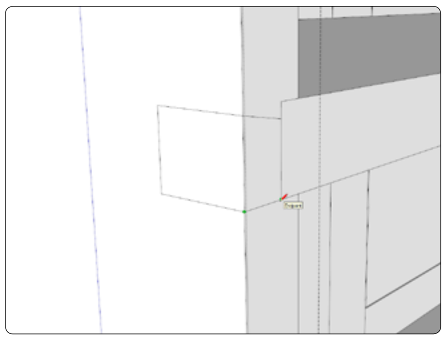


Figure 92. *Open the side for editing and trace over the dovetail shape.*

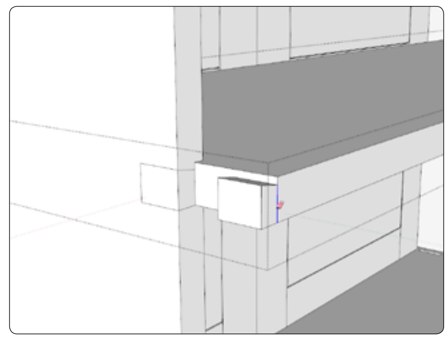


Figure 93. *Pull the shelf out and delete the extra line on the front edge.*

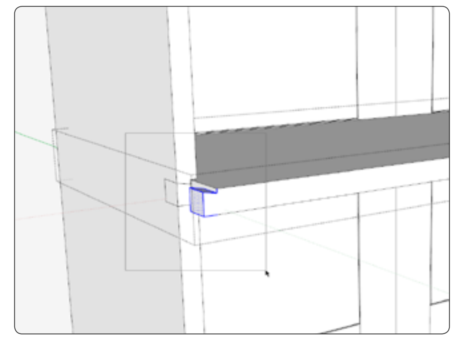


Figure 94. *Select the dovetail shape and copy it to the opposite end of the shelf.*

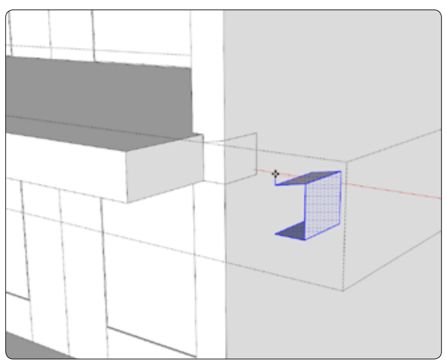


Figure 95. *Flip the dovetail shape and move it into position.*

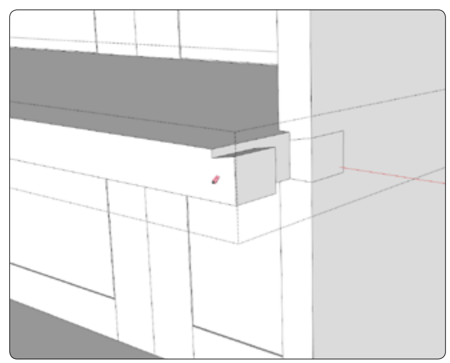


Figure 96. *After positioning the copy, clean up the dovetail shape.*

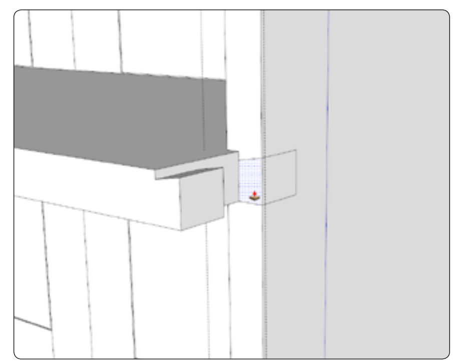


Figure 97. *Open the side for editing and remove the waste dovetail shape.*

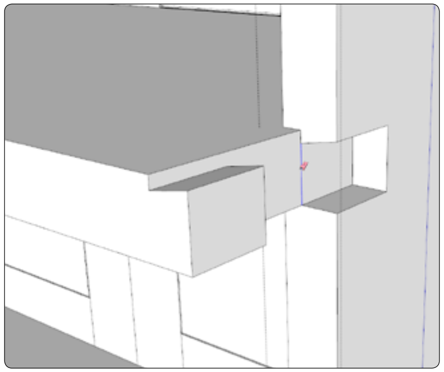


Figure 98. *Delete the extra vertical line in the side component.*

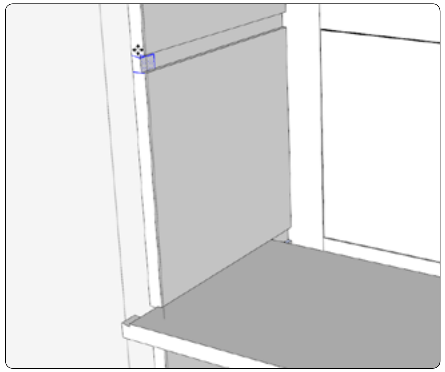


Figure 99. *Copy the dovetail joint and move it to the other shelf location.*

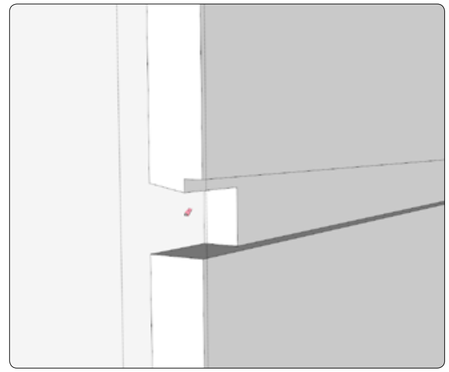


Figure 100. *After copying the dovetail, erase extraneous lines.*

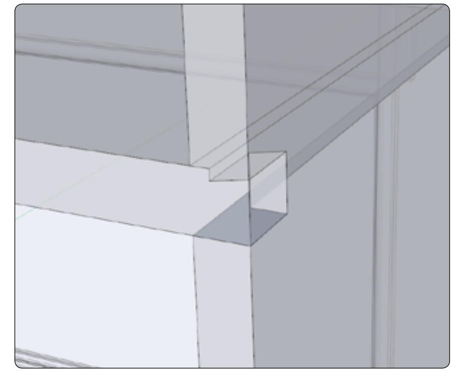


Figure 101. *The completed dovetail joint in X-Ray style.*

and move it to the opposite end of the shelf. See Figure 95. Flip the copy along the red axis and move it into place. You will need to do some cleanup to close faces and erase extra lines. See Figure 96.

Close the shelf and open the side component for editing (this time, using the right side). Use the Push/Pull Tool to remove the waste and open the dovetail socket. Stop the push 1 in. back from the front edge. See Figure 97.

Erase an extra vertical line, as shown in Figure 98. Copy the dovetail socket on the side and move it up to the other shelf locations, as shown in Figure 99. After placing the copy on the side, clean up the waste to produce sockets that look like the one in Figure 100. Copy the shelf to the other locations.

Figure 101 is in X-Ray style, showing the shelf connected to the side component. A visual inspection ensures that there is an exact fit between the side socket and the dovetail end of the shelf. Also, I can see that the shelf fits exactly within the dado across the face of the side.

Status Report

Figure 102 shows the status of the construction. Increasing the depth of the cabinet necessitated editing the dovetail and mortise-and-tenon joints in the carcase. The back panel needed substantial work. I also chose to make the shelves more complex by adding the half-dovetail joints on the front. But on a cabinet as big as this one, those joints help tie the parts together. Still, even with all the changes, it is faster to alter existing components than to start from scratch.

I've only shown two shelves, but this cabinet could handle three.

In the next section, you will enlarge the doors and remake the cove molding for the top of the case. Finally, I'll provide general instructions for building the table base. Its construction is very straightforward.

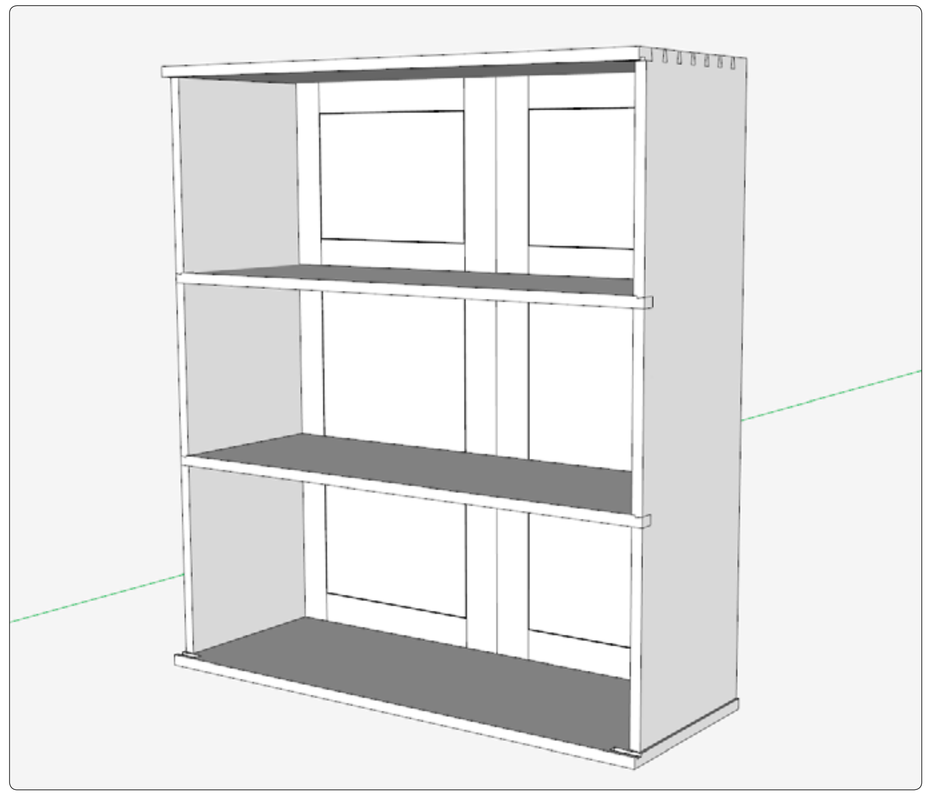


Figure 102. *The current status of the cabinet construction.*

Step 33 Figure 103 shows the original door in the new cabinet opening. We can use the Move/Copy Tool to stretch individual components, as you have before. But first use the Scale Tool to determine the new widths for the stiles and rails. The existing widths of these components are too thin to be properly proportioned for the larger cabinet.

Begin by making the entire door assembly one component. The rails, stiles, handle, and panel components will "nest" under an overall assembled component.

Click on the door assembly to select it. Now choose the Scale Tool and grab the middle upper grip (the prompt will say, "Blue Scale about Opposite Point"). Enlarge the door vertically and click on the lower edge of the top component to stop the scaling. See Figure 104.

Now begin a new scaling along the red axis, as shown in Figure 105. Use the grips with the prompt, "Red Scale about Opposite Point." Enlarge the door to the right; click the mouse on the midpoint of the front edge of the top to stop the scaling. Figure 106 shows the results of the scaling and the new, more appropriate, widths of the door components. It also shows the original door with the inner edge of the stiles lined up. That alignment is important: It will help you quickly stretch the pieces of the door frame.

Unfortunately, this scaled door has issues that prevent its use as the final door. First, the inner rabbeted edges of the stiles and rails have been increased to 7⁄16 in. when they should be unchanged at ¼ in. wide. Second, the miter angles are no longer 45 degrees due to the non-proportional scaling.

I deleted the recesses for the knife hinges in the stiles and the upper rail. These re-

Figure 103. *The original door in the new cabinet opening.*

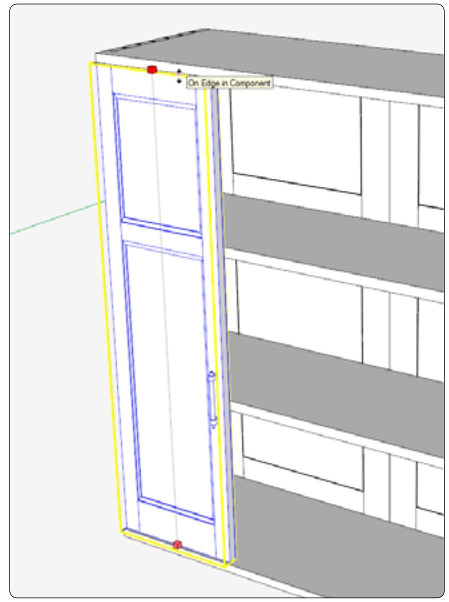


Figure 104. *Scale the door assembly vertically.*

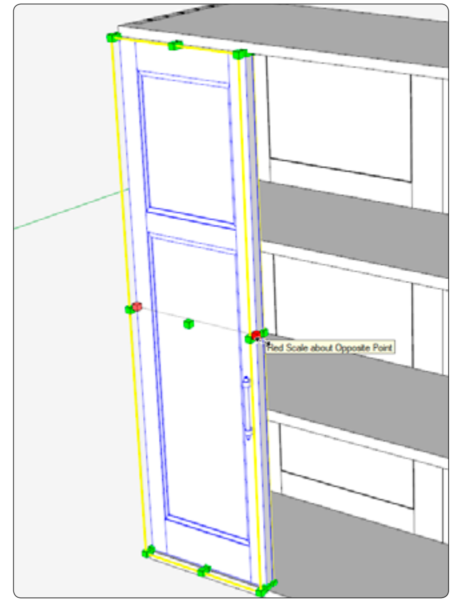


Figure 105. *Use the red scale grips to scale the door horizontally.*

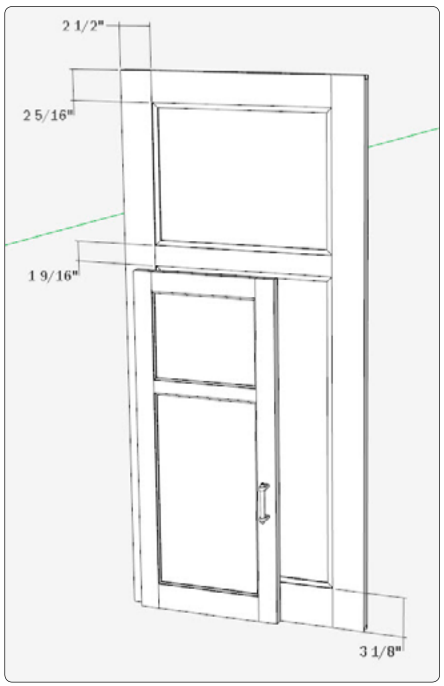


Figure 106. *New increased widths for the stiles and rails.*

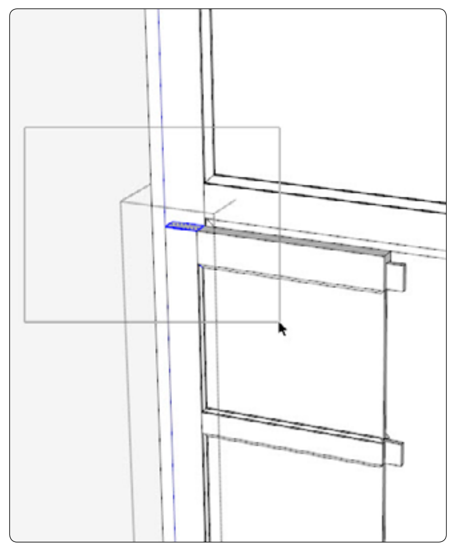


Figure 107. *Select the top joinery of the stile.*

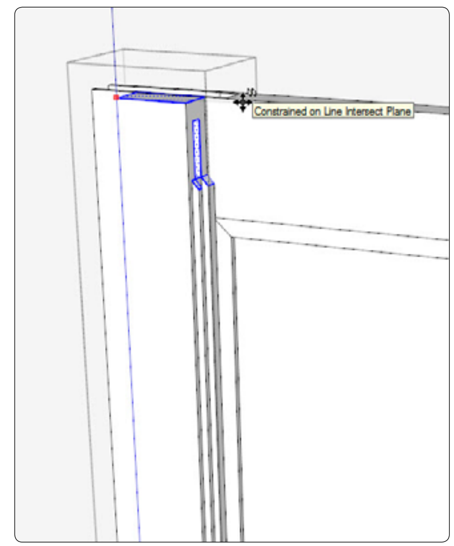


Figure 108. *Stretch the stile up to the top edge of the scaled door.*

cesses would be affected by the resizing and would need to be redone. Besides, I would be more comfortable using butt hinges on this larger door.

Step 34 As shown in Figure 107, draw a left-to-right selection box around the upper joinery of the stile. Use the Move/Copy Tool to stretch the stile up to the top of the scaled door. See Figure 108.

Select the bottom of the mortise and the miter joints, as shown in Figure 109. Then move the selected graphics down to line up with the lower edge of the upper rail. See Figure 110.

Move the original door upper rail into position on the stile, as shown in Figure 111. The original upper rail needs to widen significantly, as shown in Figure 112. Open the component for editing and use the Push/Pull Tool to raise the top edge up to the top of the stile.

Step 35 The tenon needs adjustment to match the mortise in the stile. Turn on X-Ray style and use the Push/Pull Tool to raise the top edge of the tenon up to the matching top edge of the mortise. See Figure 113.

Stretch the upper rail length to the position of the opposite stile, as shown in Figure 114.

The stile is still at its original width. Use the Push/Pull Tool to pull the outer edge to the full width, aligning with the outside edge of the scaled-up version of the door, as shown in Figure 115.

Step 36 The position and size of the mortise and miter trim in the middle of the stile need adjustment. Open the stile for edit-

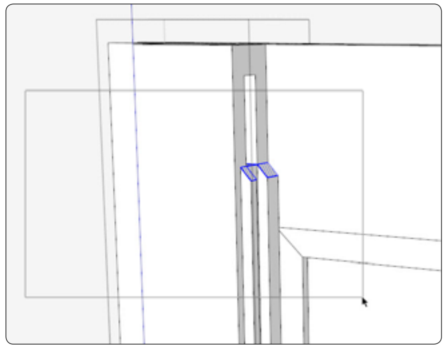


***Figure 109.** Select the lower edges of the mortise and the miter joint.*

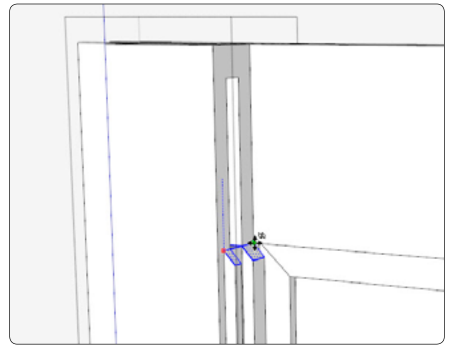


***Figure 110.** Move the miter joint down to line up with the lower edge of the top rail.*

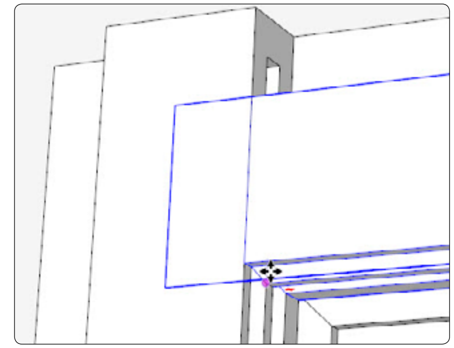


***Figure 111.** Move the upper rail so that the miters on the inner edges meet cleanly.*

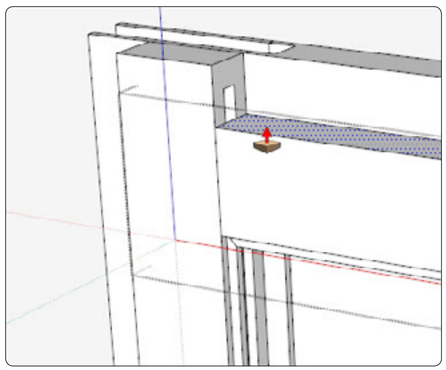


***Figure 112.** Stretch the upper rail to meet the top of the stile.*

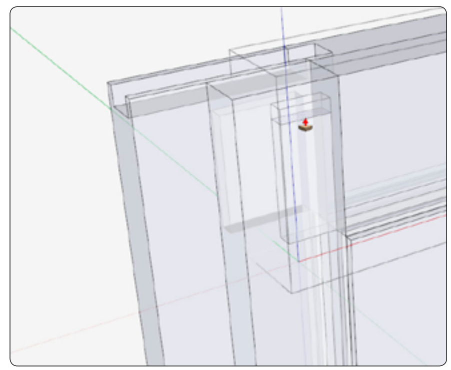


***Figure 113.** Stretch the tenon to fit the new, larger mortise.*

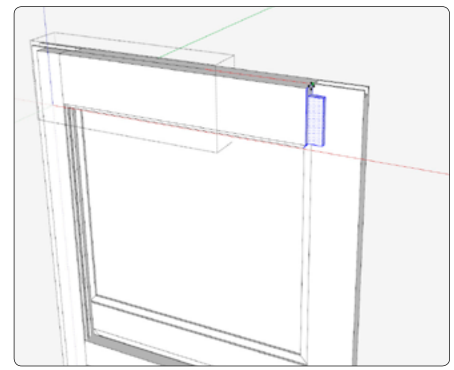


***Figure 114.** Extend the rail to meet the opposite stile.*

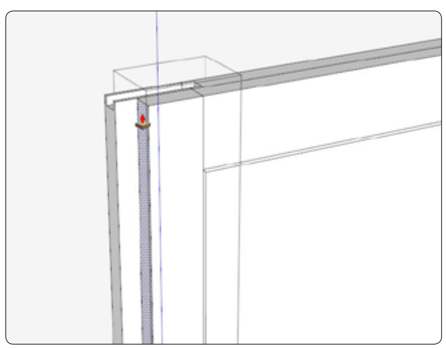


***Figure 115.** Widen the stile.*

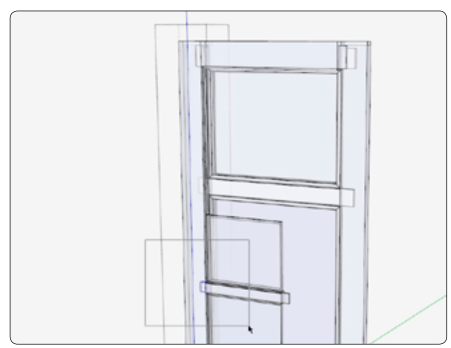


***Figure 116.** Grab the joinery in the middle of the stile.*

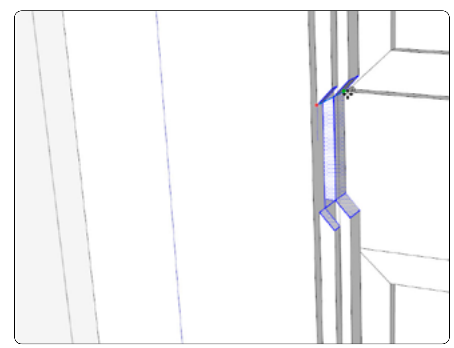


***Figure 117.** Move the mortise into position.*

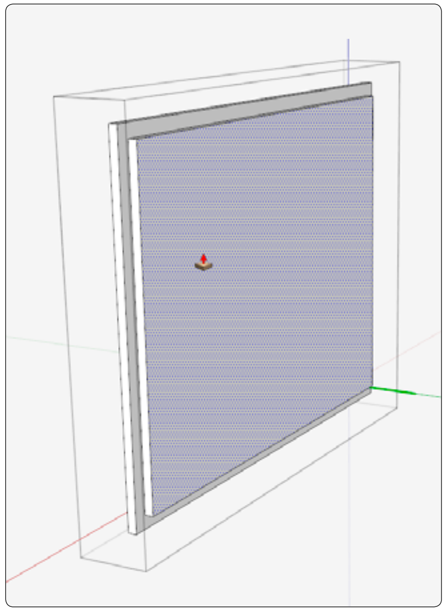


Figure 118. Increase the thickness of the panels by 3/16 in.

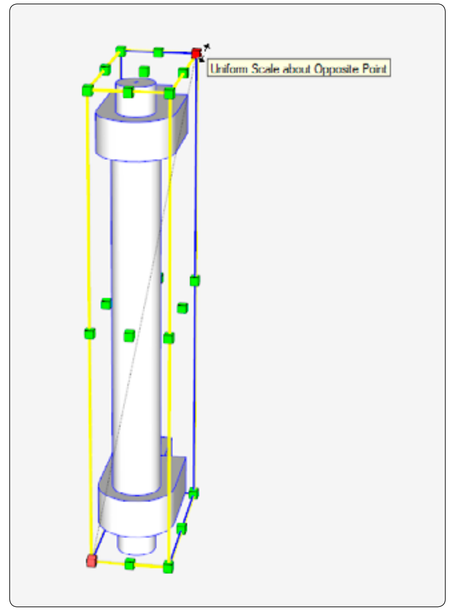


Figure 119. Select the original handle and pick the Scale Tool. Grab the corner grip.

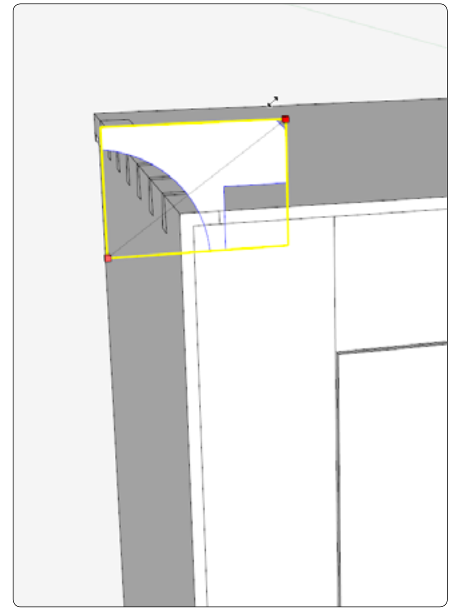


Figure 120. Scale up the cove molding shape by a factor of 1.5.

ing and draw a left-to-right selection box around the middle joinery in the stile. See Figure 116. Move the middle joinery up to its position in the larger door, as shown in Figure 117. Draw a left-to-right selection box around the lower face of the mortise and the miter joint, then lower them to their new position in the larger door.

Move the original middle rail into the new position and resize its width and tenons. Then edit the lower rail, enlarging it as you did the upper rail.

Step 37 The original floating door panels were 5/16-in. thick. Since the doors have increased in size substantially, increase the thickness of the panels by 3/16 in. That makes them ½ in. thick with a ¼-in. tongue. See Figure 118.

Step 38 The original handle is too small for the new door. Scaling produced a handle that was misshapen. Select the original handle and choose the Scale Tool. Click on a corner grip that will scale uniformly about all axes. See Figure 119. Type 1.5 as the scaling factor and press enter. This time, the handle keeps its perfectly round cross section. Explode the scaled handle and make it a new component. The handle ends have tenons that are larger than the original. Reduce them back to ¼ in. square. Modify the matching sockets created in the door stile.

Step 39 Copy the original cove molding profile to the back corner of the cabinet. Select the shape and choose the Scale Tool. Click on a corner grip, expand the size, type 1.5, and press Enter. See Figure 120. This enlarges the rabbet, so you will have to undo that. Use the Move/Copy Tool to make it ¾ in. by ¾ in., as shown in Figure 121.

Create a path on the perimeter of the cabinet top and execute a Follow Me command using the new molding shape. See Figure 122. After extruding the cove molding, fill in the miter joint lines. Add three lines: the one on the top surface, one short one on the bottom surface, and another at the rabbet joint. Use X-Ray style to place the middle and the lower lines.

This completes the design of the new upper cabinet, as shown in Figure 123.

Step 40 The upper cabinet sits atop a plain table. I'll briefly go through the steps to make the table, beginning with the legs.

Scan the orthographic drawing shown

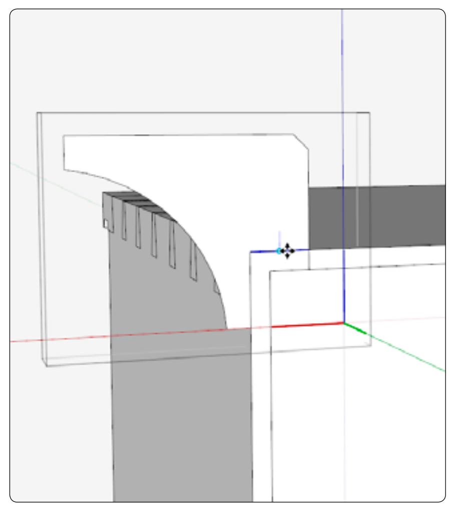


Figure 121. Reduce the size of the rabbet joint on the back edge to ¾ in. by ¾ in.

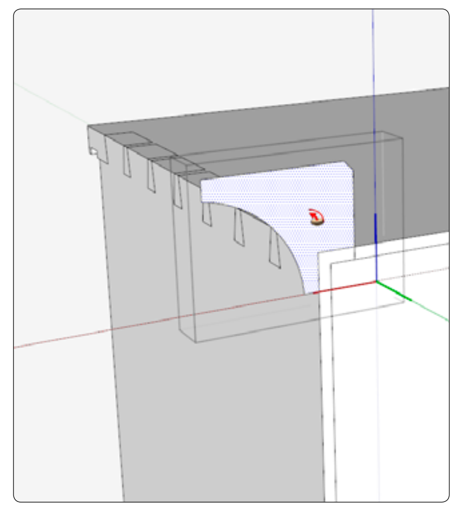


Figure 122. Select a path and molding profile for a Follow Me action.

in Figure 124, or convert the PDF to a .jpg file. Import the file as an image, make it full size, and straighten it to align with the axes if necessary. Use the Line and Arc Tools to trace over the shape of the turning. Prepare a path and execute a Follow Me command. Add the upper 2-in. by 2-in. square section using the dimensions shown in Figure 124.

In the beginning, you can work with one leg component. However, later in the process, you will need to have separate front and back leg components because of the differences in the mortises. Copy and flip the legs into the four corner positions. Figure 125 identifies the center-to-center dimensions for the four legs.

Create the side apron component. Note that it is inset 3⁄16 in. from the outer face of the leg. Create the tenons based on the dimensions shown in Figure 126. The tenons are not centered, but offset and flush with the back face of the apron. Once you have tenons on one end, copy and flip them to the other end. The back apron has identical tenons. However, the back apron is flush with the back face of the legs, not inset.

Make the front rails 1¼ in. wide by ⅞ in. thick. The only difference between the top and bottom rails is that the top rail has a tenon with a ⅜-in. shoulder. The tenon in the bottom rail is full width.

Use the tenons to make the mortises in the legs. Make the mortises for the side aprons first. Explode one leg and make it a back leg component. Copy and flip this to the other end of the table. Now you can complete the mortises for the back apron and the front rails.

Create the drawer components, using the dovetail dimensions in Figure 127.

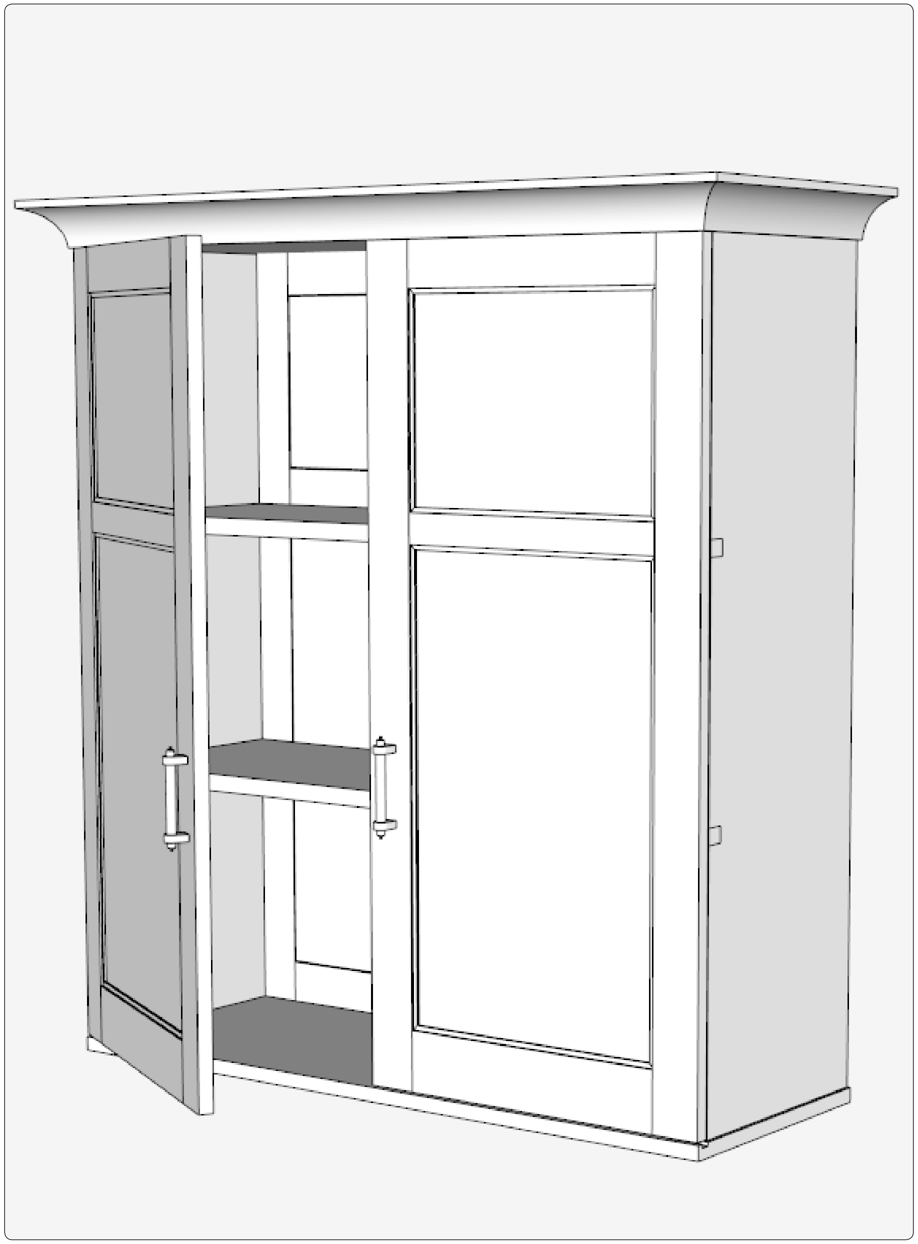


Figure 123. *The completed upper cabinet.*

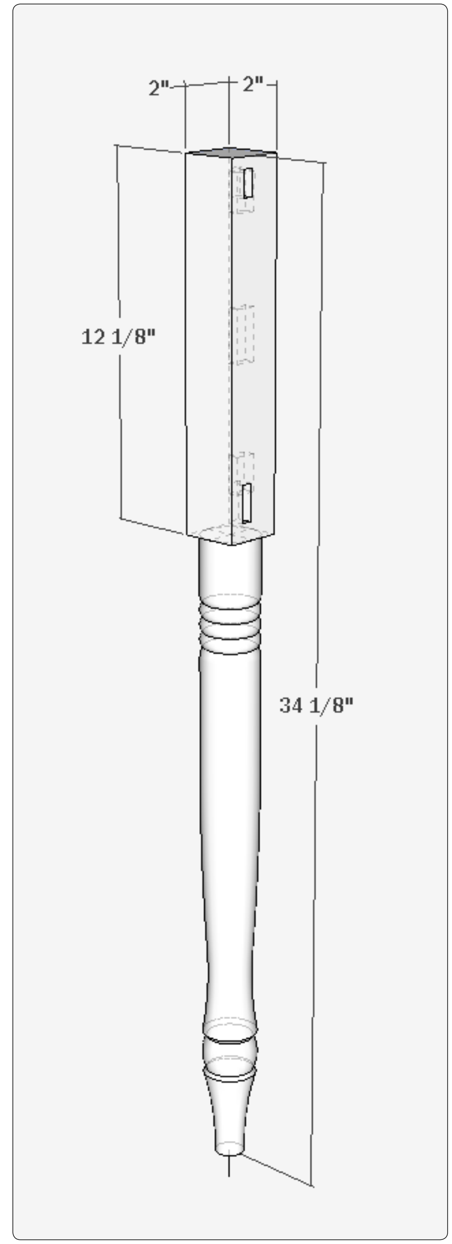
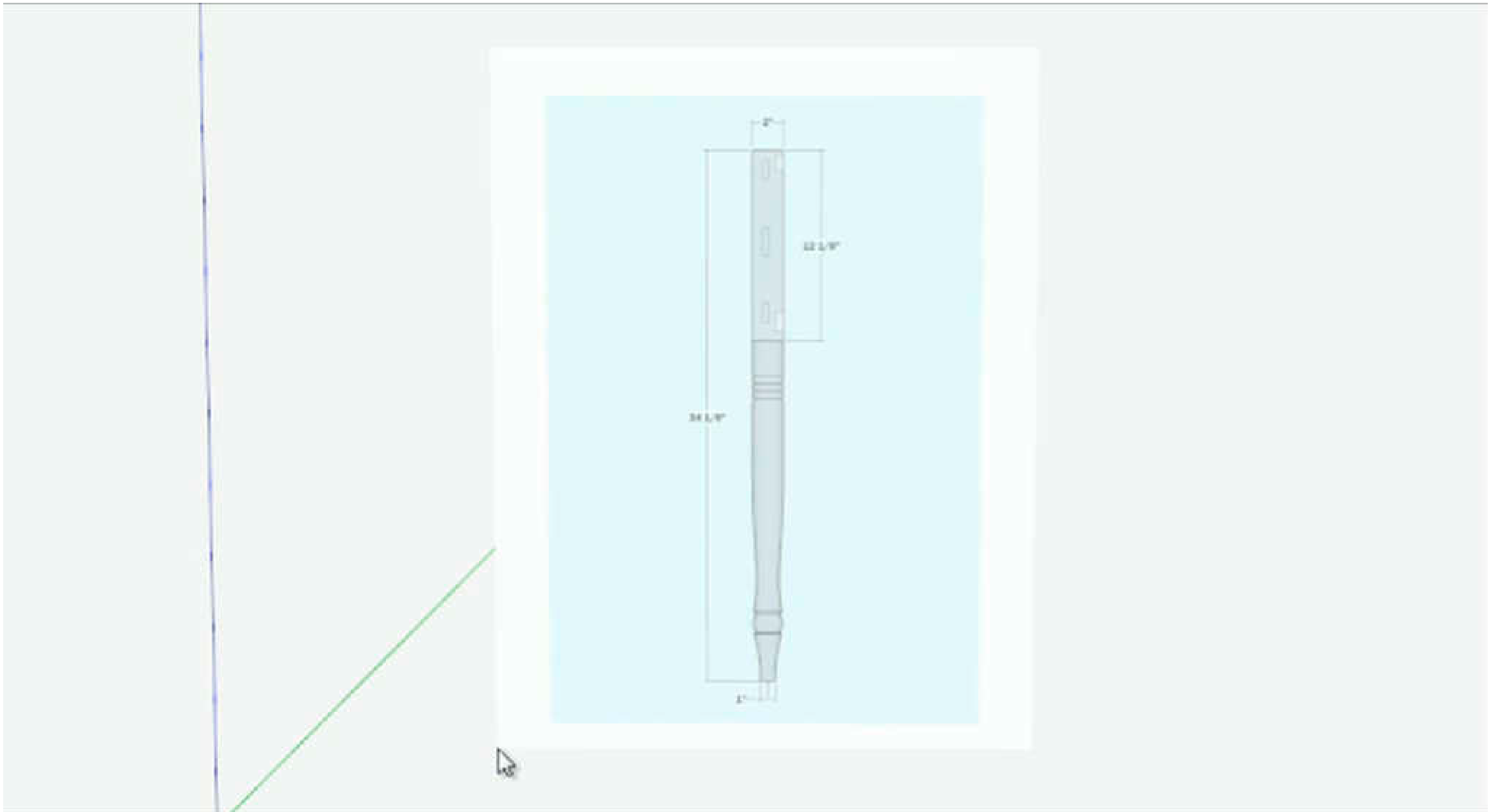


Figure 124. *Table leg.*

Video Tutorial: Turning a Table Leg

To turn a table leg, it helps to trace over an existing image that you imported into SketchUp. This video shows you how to import an image, scale it to the proper size with the Tape Measure Tool, then trace over it with the Line and Arc tools. You will see how strategically located guidelines help you make an accurate tracing. And you will see how special tags and colors that SketchUp generates helps you place multiple arc segments so that they remain on a plane and produce the shape you want.



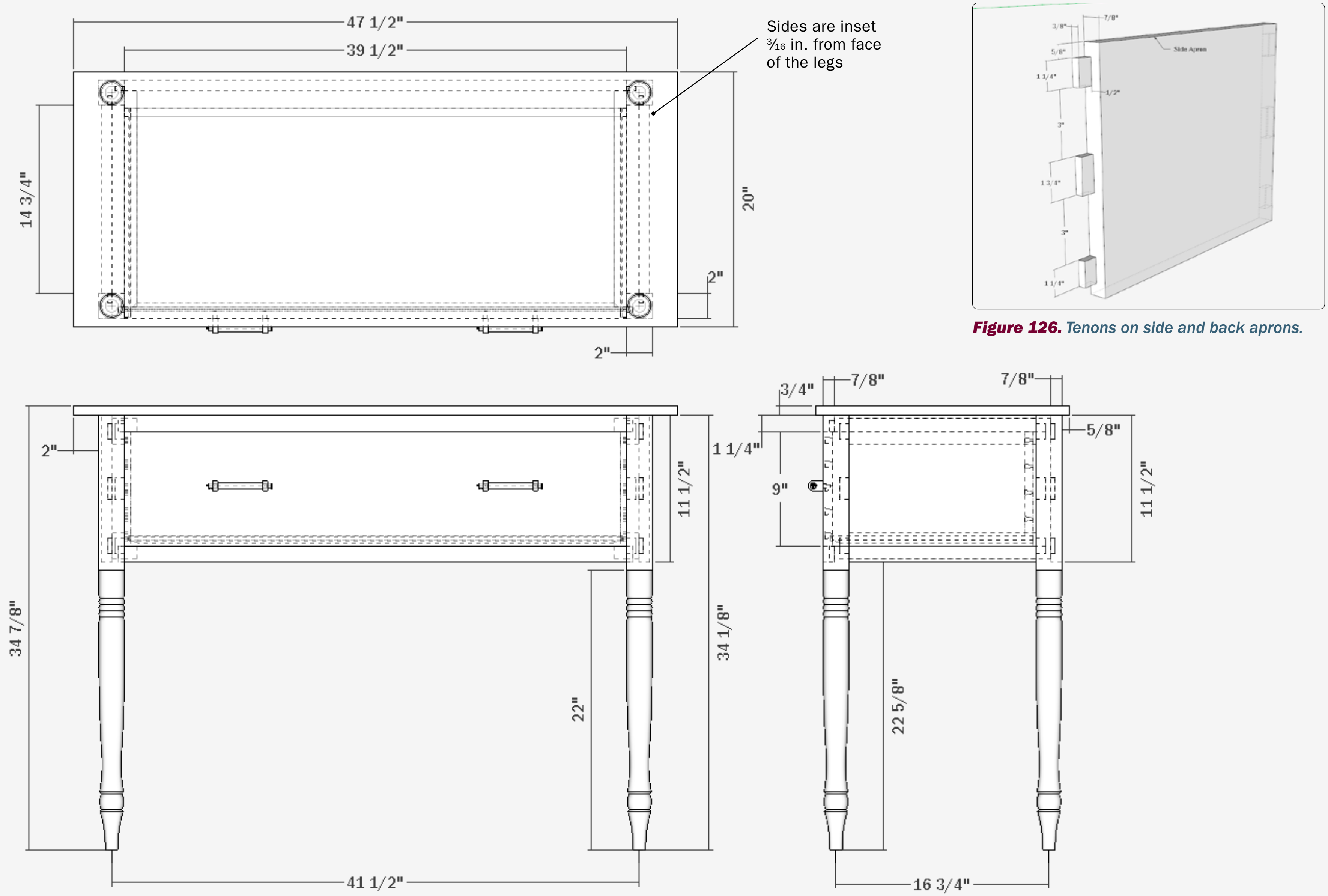


Figure 126. *Tenons on side and back aprons.*

Figure 125. *Dimensioned orthographic view of the press cupboard table.*

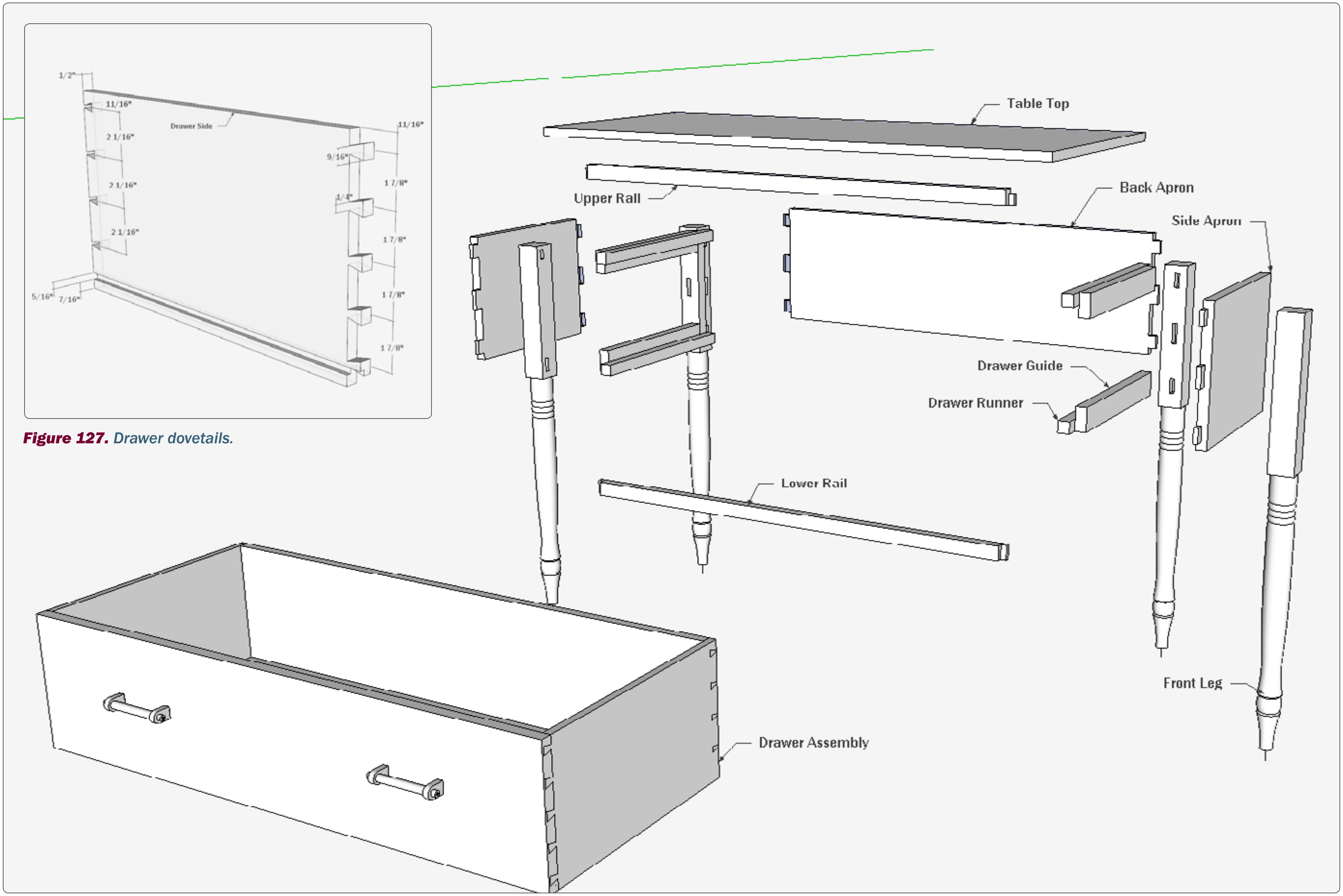


Figure 127. *Drawer dovetails.*

Figure 128. *An exploded view of the table.*

How to Assemble a Package of Shop Drawings

Having a three-dimensional model is a great asset, but it isn't enough for shop work. For that you need dimensioned drawings.

The drawings don't have to be done in pencil or ink on paper, but they must communicate where to cut, drill, rout, saw, and carve. It's not enough to have only graphical representations of shapes. A woodworker needs to know angles, lengths, thicknesses, materials, fastening methods, hardware sizes, grain direction, and notes for special procedures or sequences of operations.

When I went to college, first-year students were required to take an introductory graphics course. You could easily spot the engineering students—they were the ones burdened with T-squares, triangles, compasses, and drawing boards. Today, all they need is a laptop and the right software. One thing has not changed, however: Some of the practices we learned for adding dimensions to a drawing are still relevant; the sidebar at the right summarizes them.

Now that we're in a digital world, accurate, to-scale renderings haven't gone away. Automation makes it much easier to produce on-screen images and models. Hard copies are another matter. It would be nice to have a "Make Drawing" computer key, but until someone invents that, you'll have to go through several steps to convert a 3D SketchUp model into drawings you can print and take to the shop.

You can produce usable shop drawings with the free version of SketchUp. It does have some limitations, however, which I will cover in this chapter. The Pro version of SketchUp comes with a companion program called Layout. Its main purpose is to allow you to generate professional-looking drawings from the model. With Layout, you can add photos, explanatory text, title blocks, PDFs, and have multiple scenes on a page. I'll show how to make drawings with basic SketchUp and with Layout.

Types of drawings

In woodworking, you are likely to see drawing packages that include various types of views and documents. They include:

- Perspective views showing 3D representations of the assembled furniture and its parts. Isometric views are sometimes used; these are a kind of false perspective, constructed around three lines that are 120 degrees apart.
- Orthographic projections display three views: front, top, and right side or end. Figure 1 is an example. This is probably the most common type of drawing.
- Section views show the interior of an object as if the surface had been cut away.
- Detail drawings present separate close-up views to show important details and dimensions that cannot be communicated clearly in a larger drawing.
- Exploded views show the parts disconnected from each other.
- A cutlist is a table or spreadsheet identifying each component, along with its length, width, and thickness. It will also

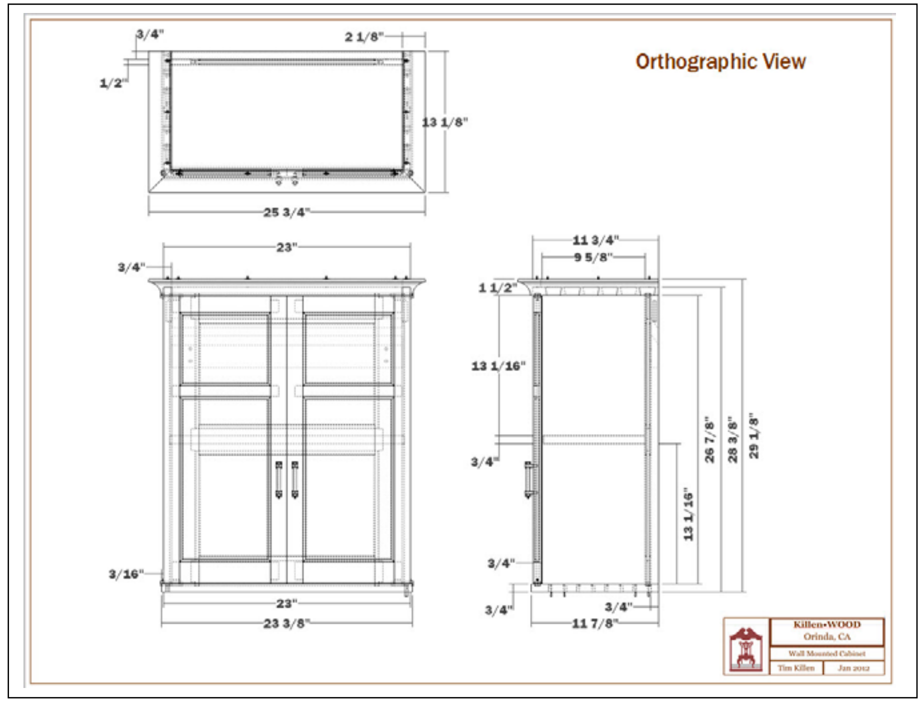


Figure 1. *My drawing format for the orthographic view of the wall-mounted cabinet. It is very much like a traditional pen-and-paper mechanical drawing.*

Classic Dimensioning Practices

I learned these dimensioning practices in my first year of college. That was a long time ago, before the advent of computer-assisted design. Nevertheless, I think they still apply.

- **Place dimensions so they are easy to read and their meaning unmistakable.**
- **Include enough dimensions so the reader does not have to make any arithmetical computations.**
- **Don't duplicate dimensions.**
- **Avoid placing dimension lines or dimension values on the component.**
- **Avoid crossing dimension lines.**

identify how many components are required and sometimes list the material and hardware.

- Templates are orthographic views of an individual component at actual size or at a stated scale. Templates are typically used for shaped and turned pieces. They are sometimes shown with a background grid at scale, to make it easier to duplicate the shape.

SketchUp will generate all of those drawing types (and more, such as X-Ray style) whether you use the free or Pro version. Once you have the SketchUp model, you can produce any drawing type with a few clicks of the mouse. If you change a component, every drawing that includes the component will be updated automatically.

When you make shop drawings by hand with triangle, T-square, and compass, you generally make them to scale: ¼ in. equals 1 in., for example. In SketchUp, of course, you "build" full-size with the ability to produce drawings in any scale. The key to generating shop drawings with SketchUp is its Scenes utility, which allows you to define, capture, and save multiple views and details.

A scene can be an overall perspective view of the complete cabinet, the associated exploded view, a full-size template, a close-up look at a specific joint, or any variation you can envision. You can generate as many scenes as you need for a given model. When you print the scenes, you have a comprehensive document to use in the shop.

I'll use the wall-mounted cabinet from Chapter 3 to illustrate how to create a drawing package. Open the cabinet model again to work through the steps shown in this chapter.

How to make and modify scenes

You should have the Scenes dialog box bundled on screen with other functions, as explained in Chapter 1 and as shown in Figure 2 with the model of the cabinet.

Click on the Add Scene icon to open a new scene, as shown in Figure 3. SketchUp adds a tab labeled Scene 1 and shows the thumbnail picture and Scene 1 identified in the open dialog box (Figure 2). Click on the Name text box and name the scene Assembly, as shown in Figure 4. The name changes on the tab and in the dialog box.

Click on the Update Scene icon, the one showing a pair of arrows chasing each other, to save the scene you just created. This saves the current view shown in the modeling window.

When you click on the Update Scene icon, another pop-up menu will appear. Click the Update button in this menu as well. Every time you update a scene, it takes two clicks.

If you modify the view in a scene by orbiting, panning, or zooming, you can easily update the scene. Open the Scenes dialog box, click on the title of the scene, and click on the Update Scene icon again.

Now you have an easy way to return to this saved view with just a click of the mouse. By creating additional scenes—showing various parts, zoomed-in views, orthographic views, an exploded view, and so on—you build a complete, comprehensive design package.

My standard scenes

Over the years, I've developed a fairly standard set of scenes. They are based mainly on personal taste, but tempered with feedback from students, customers, and *Fine Wood-*

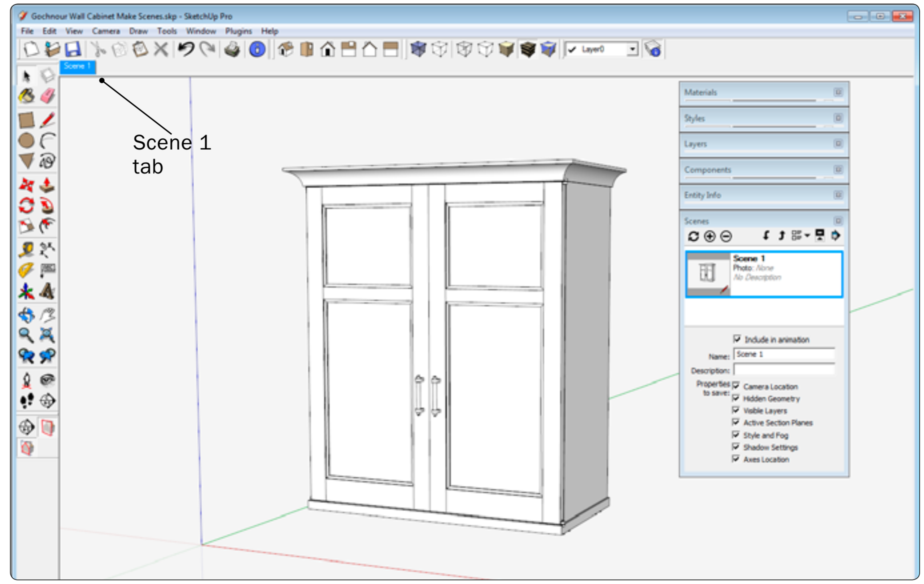


Figure 2. *The Scenes dialog box open on the assembled view of the cabinet.*

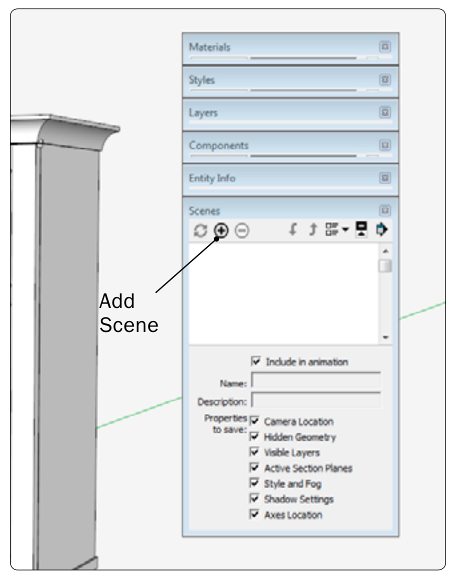


Figure 3. *Click the icon shown to generate a new scene.*

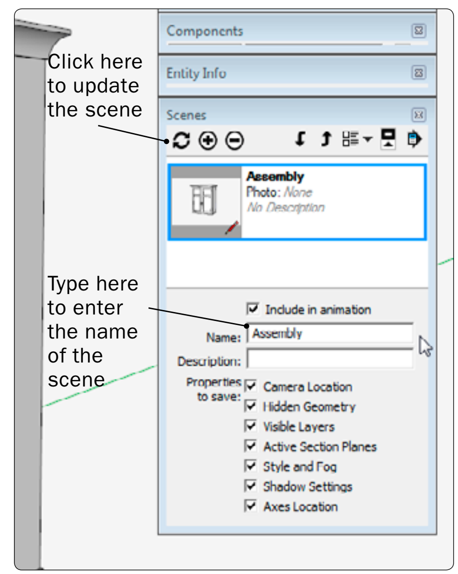
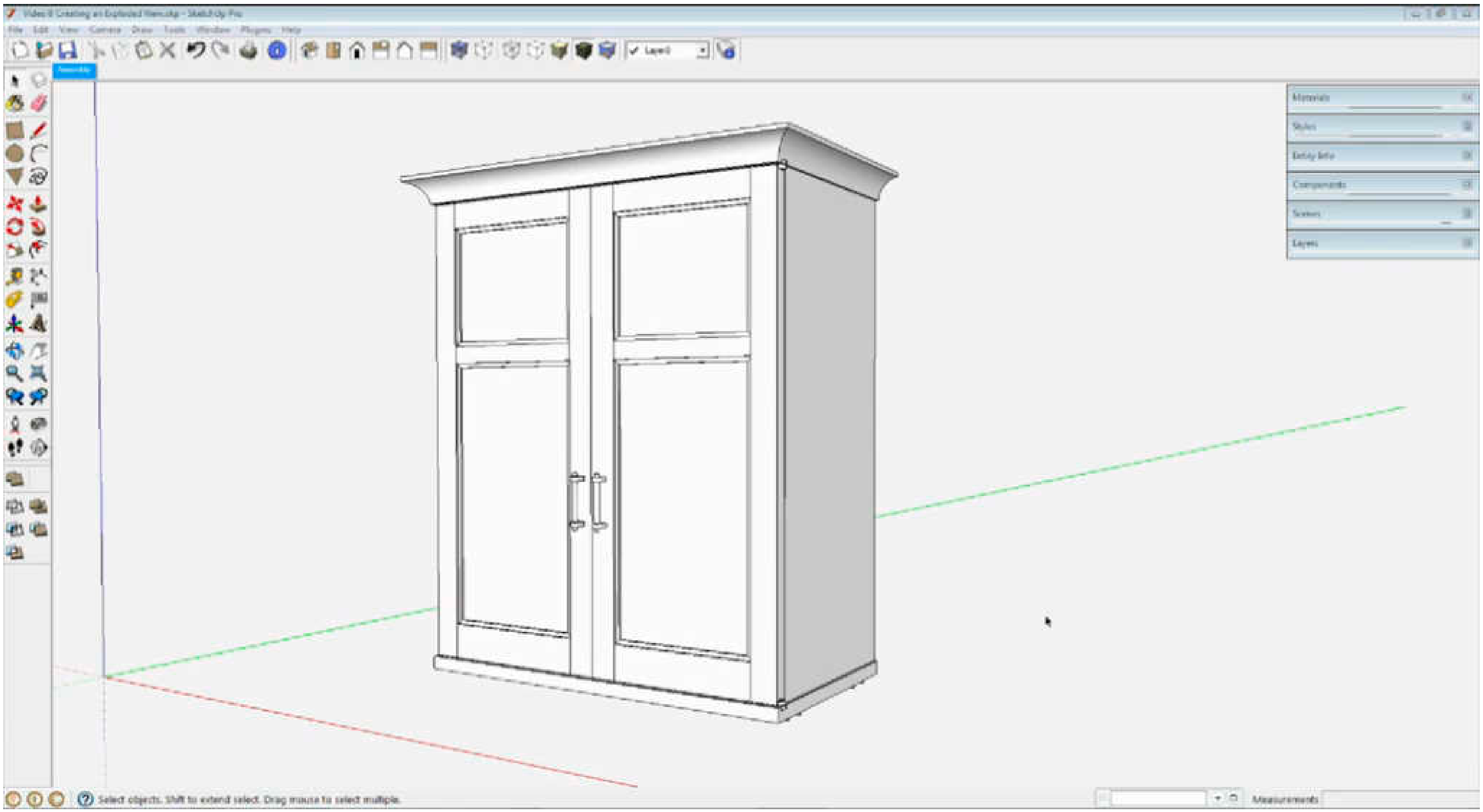


Figure 4. *Edit the name of the scene and update.*

Video Tutorial: Creating an Exploded View

In this video I will show you how to create an exploded view and save it into a SketchUp scene. The first step is to make a copy of the assembled model and move it away from the original along the red axis. After creating a scene called Exploded View, you use the Move/Copy Tool to separate the components in the model, moving them along the red, green, and blue axes. The aim is to spread out the components in order to expose all the joinery.



working projects. Here's a rundown of the scenes I normally use:

- Assembly—the overall assembly in perspective view, sometimes with a door open, if applicable, and occasionally with shadows.
- Exploded view—I pull the model apart so each component is visible, and I display the name of each component.
- Orthographic—A top, front, and end view in orthographic projection, with dimensions. I often use Back Edges style to show hidden lines and to be able to dimension those hidden features.
- Component perspective—Each component will have at least one scene, a perspective view with dimensions. I often use Back Edges style for these scenes to show hidden edges and joint details. For large components with complex joinery, the scene may require several zoomed-in close-ups. The dimensions shown on these detailed perspective views should not display on the larger overall perspective view of the component, and vice versa. To accomplish that, I use Layers for dimensions and text. I'll explain Layers later in this chapter; see page 180.
- Component template—Many components need orthographic front, side, or top views. These scenes are frequently used to create full-size templates. I often use Back Edges or X-Ray style for these scenes to show hidden joint details.

I typically string these scenes along the red axis, with each addition stepping further away from the SketchUp origin,where the three axes meet. I leave some space between the scenes to avoid having a portion of one scene visible at the edge of another. Depending on the camera view, I may have to shift a scene on the blue or green axes to avoid interferences in the background.

With practice, you will find your own preferred set of scenes.

The exploded view

Select the fully assembled model and use the Move/Copy Tool to make a copy and move it along the red axis. Use the Move/Copy Tool to pull the assembly apart one component at a time, arranging the components to suit. For clarity, some components will have to be moved farther away than others. See Figure 5.

Use the Text Tool to label each component. When you click the tool on the component, SketchUp displays the default label text, with the exact name you gave the component. If you don't like the default label, you can modify it by double-clicking the label and typing new text.

There are plug-ins for SketchUp that can be downloaded and used to automatically "explode" the assembly. I don't use them. Making an exploded view is very easy and quick, and doing it manually gives me more control over the placement of parts.

Once you have the components in the copy separated and labeled to your liking, make that view a new scene named Exploded View.

The orthographic view

I include a straight-on front, side, and top view in the final documentation. To create this scene, make another copy of the assembled model and move it farther along the red axis. Copy it again and move the second copy to one side, being sure to stay on the red axis. Go back to the first copy, make a third copy, and raise it up along the blue axis. Use the Move/Copy Tool to rotate each assembly 90 degrees, placing it into its respective top or end orientation, as shown in Figure 6.

It helps to make the overall model a named component. That way, any adjustments and changes to the overall model automatically appear in all copies in the design file. Don't worry about lining up the assemblies on the green axis. The front view will look along the green direction, so displacements along that axis won't matter.

Click on the Camera tab in the Menu bar. From the drop-down menu, choose Front for the standard view and choose Parallel Projection. Figure 7 shows the resulting view. You may need to nudge one or more

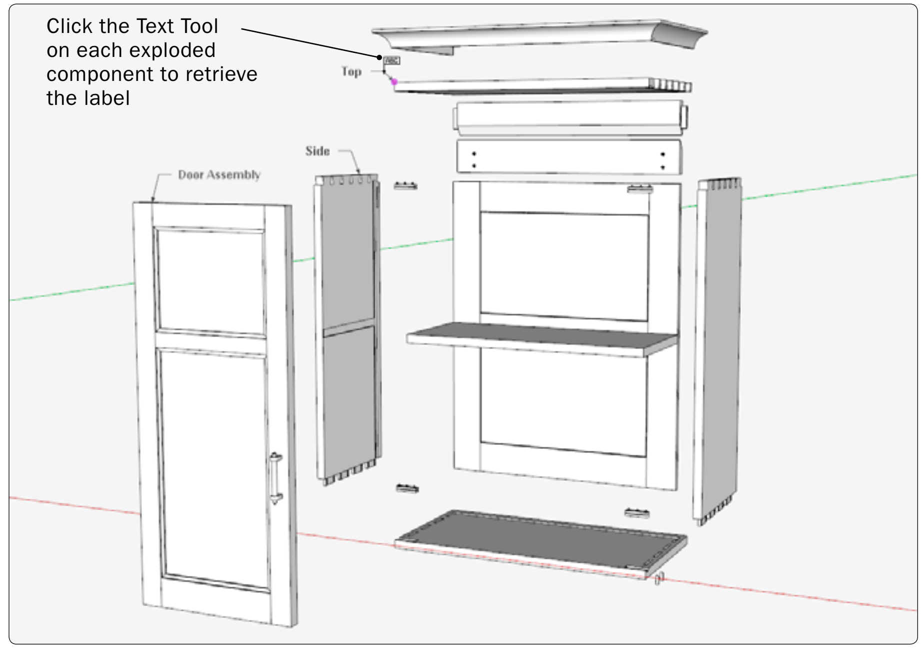


Figure 5. *Use the Text Tool to label the components in an exploded view.*

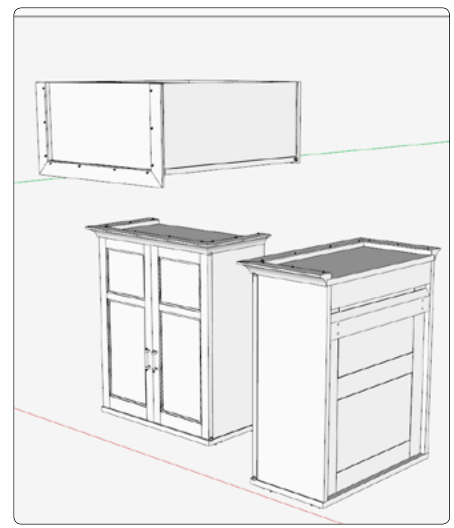


Figure 6. *To make an orthographic drawing, rotate copies into front, top, and side views.*

of the assemblies with the Move/Copy Tool to space it appropriately. Be sure to keep the moves on-axis. Open the Scenes dialog box, create a new scene named Orthographic and update the scene.

You should now have three scene tabs: Assembly, Exploded, and Orthographic. Click on each tab to switch between them.

I prefer to use Back Edges style in my orthographic views because it shows hidden geometry and joinery. For example, shelves that would not show in a normal style will appear as dotted lines in the Back Edges style. Now, I can place dimensions on the orthographic view to locate the shelves.

Clicking on the Back Edges icon in the Face style toolbar will change the view, but only temporarily. To have a Back Edges view whenever you select the Orthographic scene tab requires some additional setup with Styles. Here's what to do.

Open the Styles dialog box, as shown in Figure 8. There is only one style in the file, the Shaded With Textures default style. You need to create a new style for the Back Edges setting.

Click on the icon for creating a new style, as shown in Figure 8. A new style thumbnail will appear, as shown in Figure 9. Click on the Edit tab. The Styles dialog box will change to the edit page, as shown in Figure 10. Click on the first cubic icon from the left, for Edge Settings. Note the check box for Back Edges. Click on it to invoke the back edges setting. In the text box at the top of the dialog box, change the name of the style to Back Edges, as shown in Figure 11. Click on the Update Styles icon to save the changes to this new style. The orthographic view will immediately change to Back Edges.

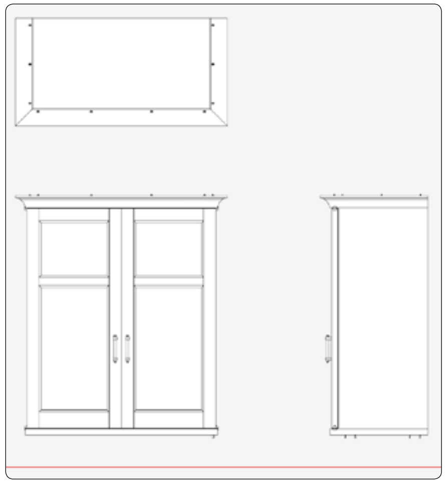


Figure 7. *In Parallel Projection, the three copies appear as two-dimensional drawings.*

There is one more very important step to finalize the scene change to Back Edges style. Open the Scene dialog box and click on the Update Scene icon. See Figure 12. The Back Edges style is now attached to the Orthographic scene. Whenever you select this scene, the view will be in Back Edges style.

Dimensions

The Dimension Tool, shown in Figure 13, is quite intuitive and simple to use. Click on one end of an object to begin placing the dimension, then move to the other end and click again. The dimension lines will appear in whatever format you have chosen.

Here is the only tricky part: As you move the mouse, the dimension lines move, too. You can decide where the dimension will finally be placed by clicking the mouse again. Depending on your view of the model, the dimension can be placed along the red, blue, or green axis. You can also place a dimen-

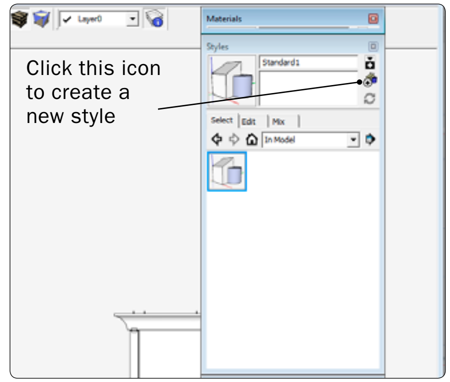


Figure 8. *To change the style for a scene, begin by opening the Styles dialog box.*

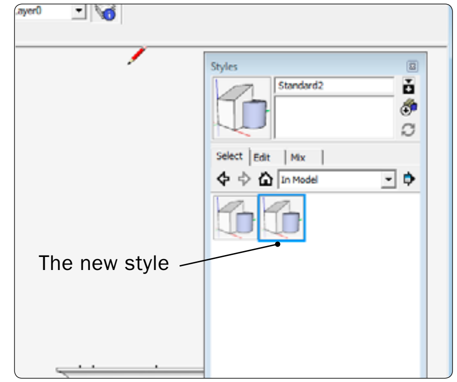


Figure 9. *When the new style icon appears in the dialog box, click the Edit tab.*

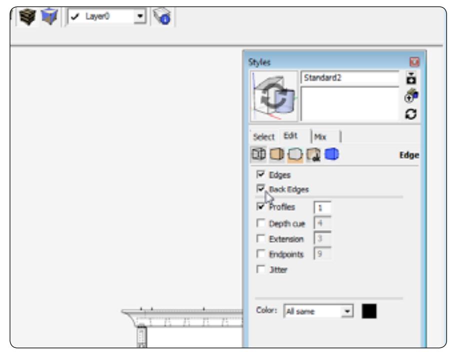


Figure 10. *Click the Back Edges check box.*

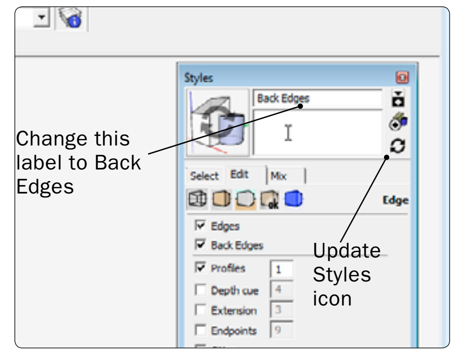


Figure 11. *Name the new style.*

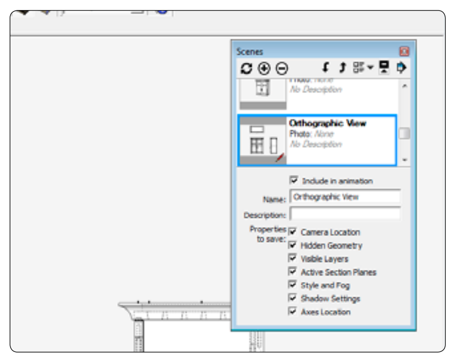


Figure 12. *Update the scene so that it always opens in Back Edges style.*

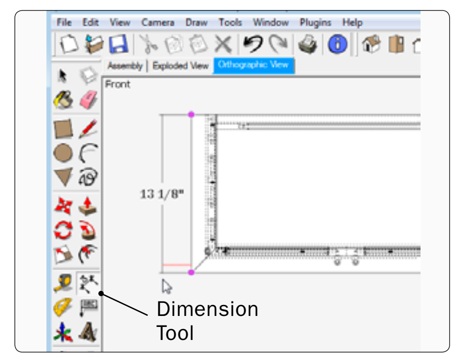


Figure 13. *The location of the Dimension Tool in the toolbar.*

sion parallel to an angled component. As you move the mouse and the dimension lines, you will see a red, green, or blue dotted line appear. It tells you which axis the dimension is aligned with (Figure 13).

If you don't like the way a dimension appears, use the Orbit Tool and try again. The options for placing a dimension very much depend on the current view. With an orthographic drawing, though, placing dimensions is very straightforward.

Here are some basic guidelines:

- Don't place dimensions within the definition of a component—that is, if you have a component open for editing. If you include dimensions within the definition, then they will appear in every copy of the component, cluttering your scenes.
- In general, I use the Text Tool to indicate dimensions of circles, arcs, and holes. You can use the Dimension Tool instead, but only within the definition of a component. And that may cause problems with dimensions showing up in unwanted places.
- When dimensioning, zoom in close to be sure you are connecting to the proper place on a component. From far away, the dimension may attach to a point close to but not exactly where you want it.
- After placing dimensions, carefully inspect their placement. Be sure that they are on the proper axis and between the correct endpoints.

There are various ways to change how dimensions are displayed. You can find many of those in the Window/Model Info/Dimensions dialog box. See Figure 14. I set Leader Line Endpoints to None. I also choose Dimensions Align to Screen.

You can also change the way dimensions are displayed on the fly by right-clicking on them. I often do this to place the numbers outside the start or end of the dimension line. See the 3⁄16-in. dimension in Figure 15, for example. You can make another on-the-fly change by highlighting the dimension with the Select Tool and choosing Entity Info from the pop-up list. See Figure 16. In the Entity Info dialog box, you can switch to "Align to dimension" and change the text size or font, text position, or type of endpoints.

After you place a dimension, you can shift its location with the Move/Copy Tool. That moves it along the existing axis but won't change its axis orientation. Sometimes this movement can be jerky and the dimension will jump in larger steps that you desire. To have more control over the movements, I sometimes select the dimension, then click the Move/Copy Tool on an edge anywhere in the model (but along the axis of desired movement). Now when you move the mouse, the adjustment of the dimension is smoother, incremental, and controlled.

The Dimension Tool can also be used to nudge and bump the location of a previously placed dimension. Hovering the tool over the dimension automatically selects it, and the cursor changes to the Move/Copy shape.

Use layers to manage views

Like Photoshop and other drawing or image-handling programs, SketchUp lets you create layers to show or hide different elements for a drawing. In SketchUp, you can associate a layer to a specific view, but I only apply those specific layers to the dimensions and call-out text. I leave all the basic graphics (lines, edges, faces, circles, arcs, etc.) on Layer 0. In fact, I initially place all dimensions and call-out text on Layer 0, but later revise these to the specific view layer. In that way, I never change from the active default Layer 0. This helps me avoid creating a jumbled mess on different layers and not having the proper things appear in the scenes.

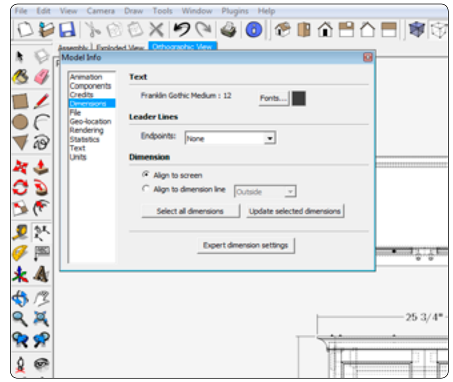


Figure 14. *Modify the way dimensions are displayed using the Model Info dialog box.*

Using Layers as I recommend means that you will be accessing both the Layers dialog box (to define what layers show in a specific scene) and the Layers Toolbar (to assign a specific layer to dimensions and text). They do different things and need to be coordinated. Be sure both features are on your screen and within your SketchUp template.

In general, having dimensions on Layer 0 (the default layer) will work. However, this will likely require you to create more copies of components, each with a separate scene, to isolate dimensions specific to the views. For example, the detail dimensions shown for a close-up view will be unreadable in the zoomed-out overall view of the component. So you would need to have one copy of the component for the close-up detailed view and another for the overall view.

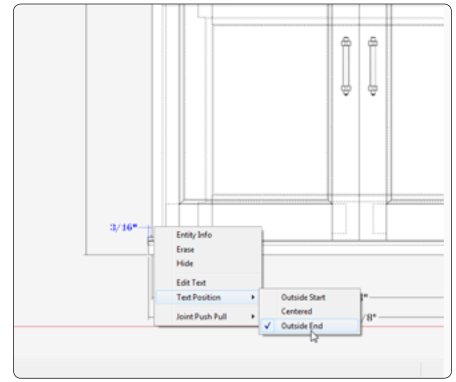


Figure 15. *Right-click on a dimension to change the text position on the model.*

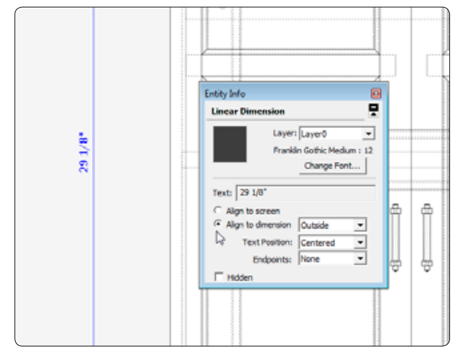


Figure 16. *Select the dimension, choose Entity Info, then switch to "Align to dimension."*

I find it useful to apply dimensions to layers that are assigned to typical camera views. That gives me more control over which dimensions are displayed when I have more than one view for the same component. I set up five layers within my SketchUp template: Detail View Dimensions/Text; Perspective View Dimensions/Text; Front View Dimensions/Text; Side View Dimensions/Text; and Top View Dimensions/Text.

By using these alternative layers for di-

mensions and call-out text, I can have five different views of the same component, all showing the dimensions in the clearest, most appropriate way.

The next section shows how to assign elements to a specific layer.

Make a component scene

When I create component scenes, I typically copy the components from the Exploded View. You can copy one of the side components in the wall-mounted cabinet and move it along the red axis. Arrange a perspective view similar to the one shown in Figure 17. Open the Scenes dialog box, make a new scene named Side, and update it. Place overall dimensions like those shown in Figure 17. Use the Orbit Tool and watch the color of the dotted lines to be sure dimensions are properly aligned. On a large component like this, it is impractical to place detail dimensions for the joinery. For that you will need separate close-up views.

Open up the Layers dialog box, as shown in Figure 18, and click on the box to place a check mark on the Perspective View Dimensions/Text layer. Be sure that the only other check mark is on Layer 0. That is the default layer. Don't change it.

Open the Scenes dialog box and update the scene. If you don't, the layering of dimensions will not work as intended. With the Scene updated, only Layer 0 and Layer Perspective graphics will be displayed.

The dimensions you placed on the side are currently on Layer 0. To change the layer for those dimensions, use the Select Tool, hold down the Shift key, and click on each dimension in turn, as shown in Figure 19. Click on the Layers toolbar and select Perspective View Dimensions/Text. That shifts all the selected dimensions from Layer 0 to the perspective layer but does not change the default layer.

If you reverse the process, picking a layer on the Layers toolbar first, you will change the default layer. You'll probably forget that happened and end up with a mess of graphics on unintended layers.

Create a detail component view

Often a component requires multiple views to show all the necessary dimensions. In this case, only overall dimensions could be placed on the side perspective view. Readable dimensions could not be placed on the complex joinery at the ends. Here's how to create a detail component view.

On the same copy of the side component, zoom in close on the top dovetail joinery. Open the Layers dialog box, select Detail Dimensions and Text, and uncheck the perspective dimension layer. Open the Scenes dialog box and create a new scene named Side Dovetail Joinery. Update the view. See Figure 20. You should not see any of the previous dimensions that were already placed in the overall side scene.

Now you can place detailed dimensions for the dovetail joints. Select all the dimensions, open the Layers toolbar, uncheck Perspective, and check Detail Dimensions and Text. These new dimensions will not be seen in the previous overall perspective scene.

Create a template view

One of the wonderful byproducts of SketchUp is the ability to make full-size templates. My students and I regularly print these templates and use them extensively in the shop.

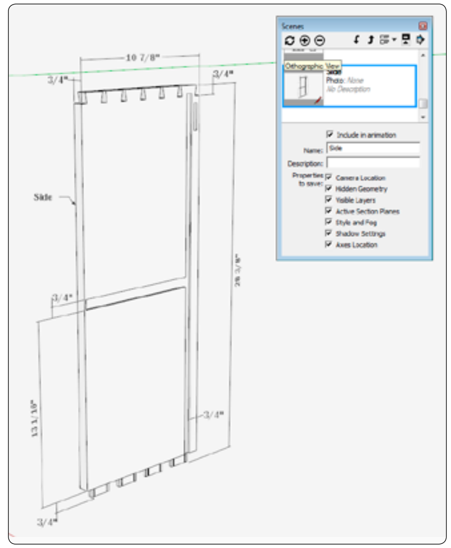


Figure 17. *Make a component scene using the wall-cabinet side.*

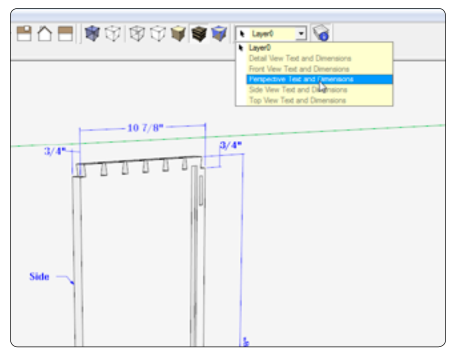


Figure 19. *Move all the dimensions to the perspective layer in the Layers toolbar.*

Here's how to make a template.

With the Perspective View of the side dovetails on the screen, click on the Right Side icon in the Standard Views toolbar. Click on the Camera tab in the Menu bar and choose Parallel Projection from the drop-down menu.

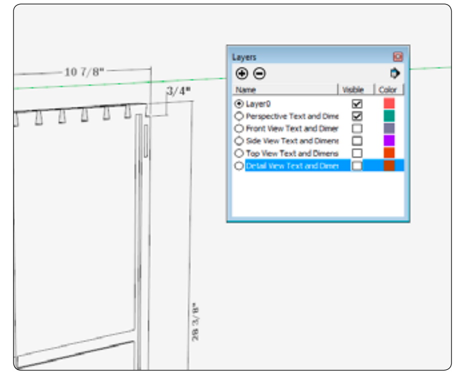


Figure 18. *Open the Layers dialog box to check the appropriate layer for this scene.*

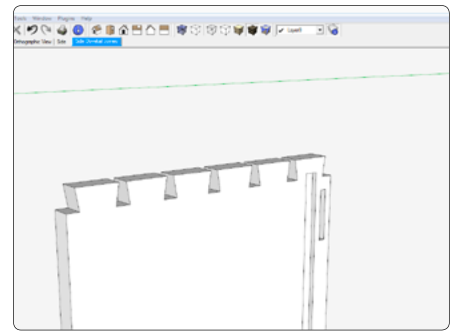


Figure 20. *Zoom into the dovetail joinery and create a new scene. Add dimensions.*

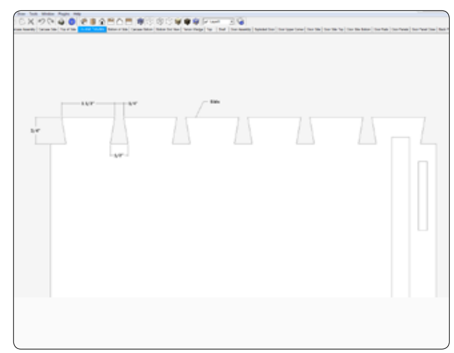


Figure 21. *The template view of the side dovetails.*

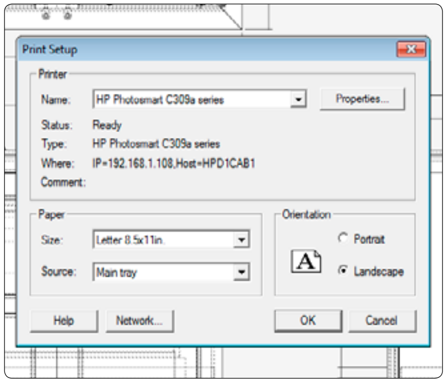


Figure 22. *The Print Setup dialog box in Windows.*

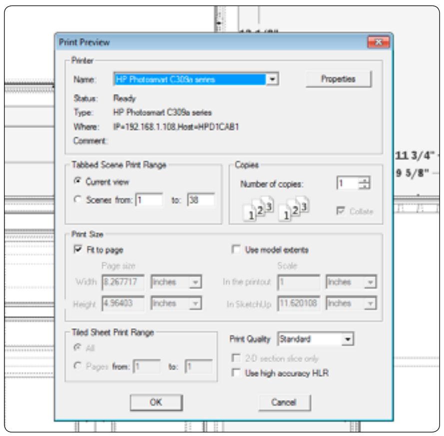


Figure 23. *The Print Preview dialog box in Windows.*

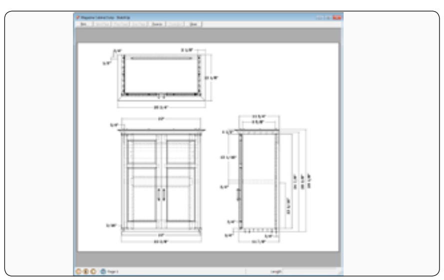


Figure 24. *The Print Preview Screen.*

Open the Scenes dialog box, add a new scene named Side Dovetail Template, and update it. You should now have a view and a saved scene like the one shown in Figure 21.

I've added more detailed dimensions to this template view, but we don't want the new dimensions to show in the perspective side scenes. To do that, open the Layers dialog box, check the Side View Dimensions/Text layer, and uncheck the Perspective View Dimensions/Text layer. Open the Scenes dialog box and update the Side Dovetail Template scene. Place the new detailed dimensions and select them with the Select Tool as you hold down the Shift key. Click on the Layers Toolbar and choose the Front View Dimensions/Text layer.

To see how you've done with the layering of dimensions and the different face styles, click on the different scene tabs. You can use these same procedures to create unique scenes for the other components.

Printing templates and other scenes

In the free version of SketchUp, each printed page corresponds to one saved scene. Except for full-size templates, the number of pages equals the number of scenes in the SketchUp model. Because of their size, templates require multiple sheets; the trick is to print them without wasting paper.

I'll explain how to set up scenes and templates to print on Windows computers first, then on Macintosh computers. "Create a drawing package in Layout" on page 184 covers the expanded printing options available with the Pro version of SketchUp.

Print setup for Windows Click on the File tab in the Menu Bar and click on Print Setup. This opens the Print Setup dialog box, as shown in Figure 22. Select the printer you will use, then set up the page size, source, and page orientation. My preference is landscape, as this fits well with the computer screen. Click OK when you have finished.

Click on File in the Menu Bar again; this time, select Print Preview to open the Print Preview dialog box, as shown in Figure 23. I prefer using Print Preview because it gives me a chance to see the results before committing to print and possibly wasting paper. This dialog box gives you the option to print the current view, all pages, or any range of the saved scenes. For Print Size, check Fit to Page for general printing. Uncheck it when printing full-size or scaled drawings. For furniture-type SketchUp files with multiple scenes, unclick the Use Model Extents box. I set print quality to Standard, and I ignore the Use High Accuracy HLR box; leave it unchecked.

Click OK to display the print preview, as shown in Figure 24. Scroll through the document or the selected scenes you have chosen to print. You can choose to see one or two pages at a time. If you like what you see, then click the Print button. The Print dialog box will return; click OK to finish the job. If you aren't satisfied with the print preview, click the Close button to back out and make your adjustments.

That's all there is to it for simple printing on Windows computers.

Print setup for Macintosh Click on File in the Menu Bar and select Page Setup, as shown in Figure 25. This opens a new screen, as shown in Figure 26. Use this screen to set up the printing for landscape orientation.

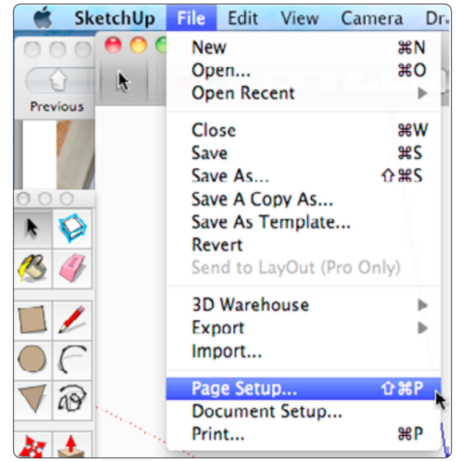


Figure 25. *The Print Setup dialog box for Macintosh.*

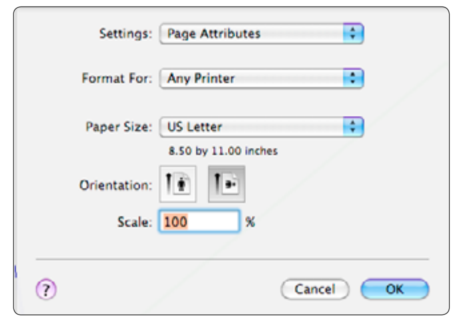


Figure 26. *The Page Setup dialog box on the Mac, where you select the printer.*

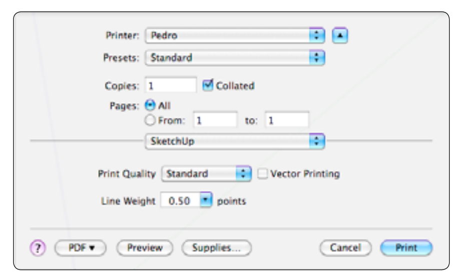
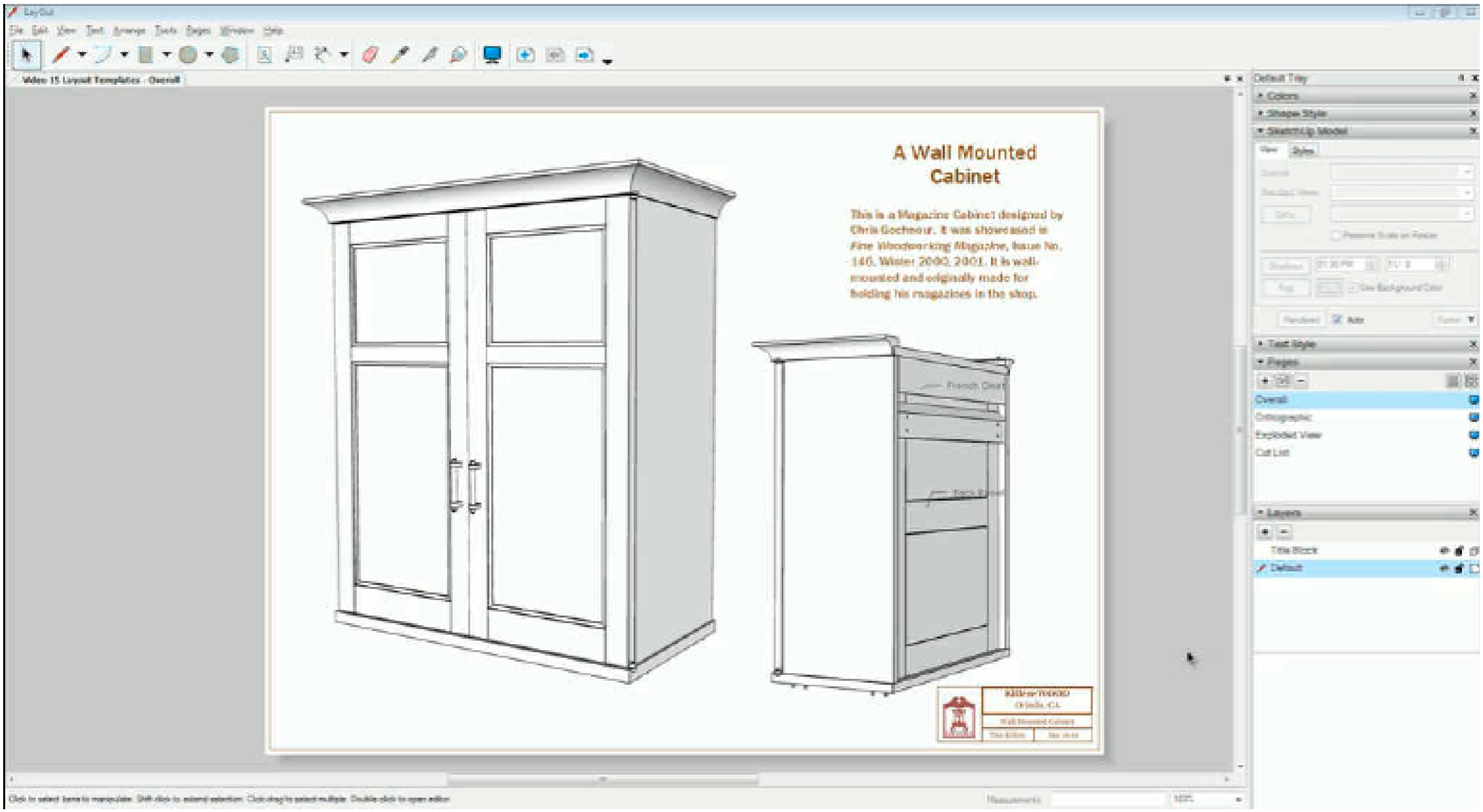


Figure 27. *One button at the bottom of the print screen lets you select Print Preview.*

Video Tutorial: Making a Template Page in Layout

Full-size templates are extremely helpful in the shop when you have to lay out parts, carve shapes, and position joinery. A key strength of using SketchUp is its ability to produce these full-size templates. They can be created in the free version of SketchUp, but this video shows how to make them in the Pro version using Layout. Layout has the added advantage of allowing you to produce full-size templates on large-size paper in the PDF format.



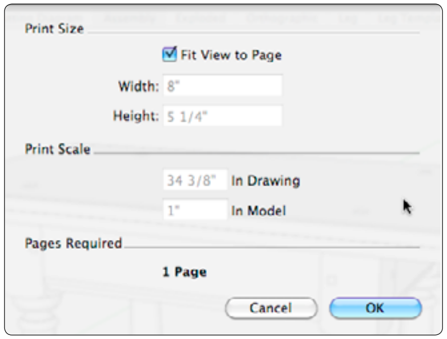


Figure 28. *The Print Preview setup page on the Mac.*

Figure 29. *The Print Preview dialog box in Windows.*

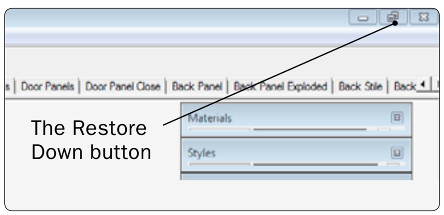


Figure 30. *The button to adjust window size.*

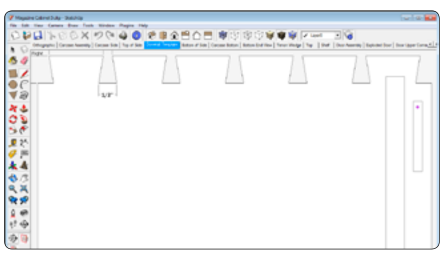


Figure 31. *The component fills the window.*

After completing the page setup, click on File in the Menu Bar again. This time, choose Print from the menu, which opens the Print screen, as shown in Figure 27. Click on the Preview button. This opens the box shown in Figure 28. Check the Fit View to Page box, then click OK. Scroll through the previewed pages and click the Print button if you're satisfied with the output. If not, you can back out of Preview and make adjustments to the scene or the page settings.

How to print full-size templates There are two key things to remember about making templates in SketchUp. First, the Scene or the view in SketchUp must have the Camera set to Parallel Projection. You cannot print a full-size template if the Camera is set to Perspective mode.

Second, the view must be set to one of the standard views, such as Top, Front, Right, or Left. When you set a standard view, avoid using the Orbit Tool on that view, which negates the standard view setting. You can use the Pan Tool but not the Orbit Tool.

I'll use the side dovetails as an example to show how to print a full-size template.

Click on the Dovetail Template Scene; this opens the view shown in Figure 29. It's in Parallel Projection and Right Side View.

If the printer can handle only 8½-in. by 11-in. paper, the template will have to be printed on multiple tiled pages. The trick is to arrange the view of the component to minimize the number of sheets needed. This is my preferred method with the free version of SketchUp.

In the upper right-hand corner of a Windows computer are the three buttons to Minimize, Restore Down, and Close the active screen. (Similar buttons are in the upper-left-hand corner on Macs.) Figure 30 shows the buttons. Click on the middle button, for Restore Down, then adjust the size of the window to eliminate as much white space as possible (Figure 31).

Click on File in the Menu bar and choose Print Preview from the drop-down menu. That opens a dialog box like the one shown in Figure 32. Be sure that Fit to Page is not checked, that Use Model Extents is checked, and that the Scale is set to 1 to 1. I set the page orientation to Landscape, which is better for the wide component. The Print Range shows only two pages, which is what you want to see. Click OK.

Click the Print button, then click OK in the Print dialog box.

This method has one drawback: It often jumbles the Toolbar positions at the top of the SketchUp screen. So I must return the Toolbars to their original single-line location whenever I have to use this technique to print a template. SketchUp provides a special command to return a saved position of Toolbars. You can find this under the View Tab/Toolbars/Restore Toolbar Positions.

Create a drawing package in Layout

The Pro version of SketchUp comes with a companion program called Layout. Its main purpose is to allow you to produce professional-looking drawings from the model.

Layout also gives you the best options for making full-size templates. You can bundle many templates on one page, print on large sheets, and export the pages as Adobe PDF files. I use Pro and Layout exclusively when I package templates for my students or customers. By printing on a 24-in. by 36-in.

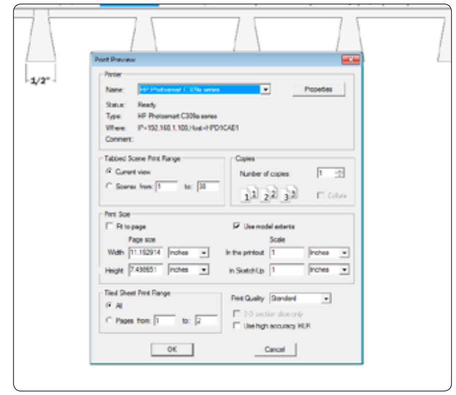


Figure 32. *The Print Preview dialog box setup for templates.*

sheet, for instance, I can usually arrange all the templates on one sheet as a PDF file; it's a handy and ubiquitous format. You can print the PDF files with Adobe Acrobat on a small home printer and patch the pages together. Or, for less tedium, you can send the file to a local print shop to output on a large-format printer.

You can also place dimensions in Layout. However, I prefer to do them in SketchUp. Layout is currently limited to orthographic dimensions only, not perspective. To me this is a significant limitation since I think it is most effective to have dimensions on perspective views as well.

Like SketchUp, the Layout interface for Mac OS X looks different than that for Windows. However, most operations are very similar and accomplish the same things.

In this section, I'll briefly show you how I make drawings with Layout. This will not be a detailed tutorial but a general presentation of how Layout works with SketchUp and how it can be used to enhance drawing output.

Introduction to Layout Figure 33 shows the full Layout screen with the first page of the drawing for the wall-mounted cabinet. This page includes two scenes from SketchUp, the Assembled View and the Back View, and a small paragraph of text. The scenes and text are embedded in a standard sheet format I created that includes a title block and a frame border. Layout offers various built-in templates for these features, but you can create your own. Also, you have the option to select standard paper sizes for your documents. I typically use two separate Layout files for each piece of furniture: one 8½ in. by 11 in. for the multipage drawing details and notes and another 24 in. by 36 in. for the full-size templates.

For each Layout file, you specify the reference SketchUp file or files (you can have multiple SketchUp files) in a File/Insert function. You select the file from your operating system's file directory. The inserted files are listed in a Document Setup dialog box like the one shown in Figure 34. In this case, I only have two inserted files, the cabinet's SketchUp file and a .jpg used for the title block.

Inserting and arranging scenes Each SketchUp scene in Layout is held within an adjustable frame. These frames can be copied, pasted, and modified to contain a different scene. Figure 35 shows the frame surrounding the carcase side. After placing the scene, you can adjust its size, move it on the page, or even rotate it. Right-clicking on the frame displays a menu, as shown in Figure 36. When you choose Scenes in this menu, another fly-out menu lists all the scenes within the reference SketchUp file. You can choose any scene from the list and it will immediately appear in the frame.

When you adjust the size of a scene, Layout maintains original text size, including the dimension text. Therefore, text size is consistent across the document no matter what variations exist in scene size.

If you double-click on a scene in Layout, you can orbit, pan, and zoom as if you were operating in SketchUp. Therefore, you can adjust the camera view of a specific scene.

Building up the document is a matter of appending blank pages, inserting scenes, adjusting scene sizes, and adding text notes. My SketchUp file for the wall-mounted cabinet contains 38 scenes, and I'm able to have a corresponding Layout with only18 pages.

When making a Layout document, I often realize that I need to make a change or an addition to the original SketchUp file. This could be a result of a missing or awkwardly placed dimension or of a need for an entirely new scene. I will go back to SketchUp, make the modification, and save the file. When I return to Layout, I "Update the Reference" by right-clicking on any scene and choosing that option from the pop-up menu. All the scenes in Layout are immediately updated with the changes made in SketchUp. Any new scenes are now available to be placed in Layout.

Making full-size templates in Layout With Layout you have the best options for producing full-size templates. By selecting large-scale paper, such as Arch D size (24 in. by 36 in.), you can fit most of your templates. This, in conjunction with the ability to produce a PDF file, gives you a way to distribute and print the document.

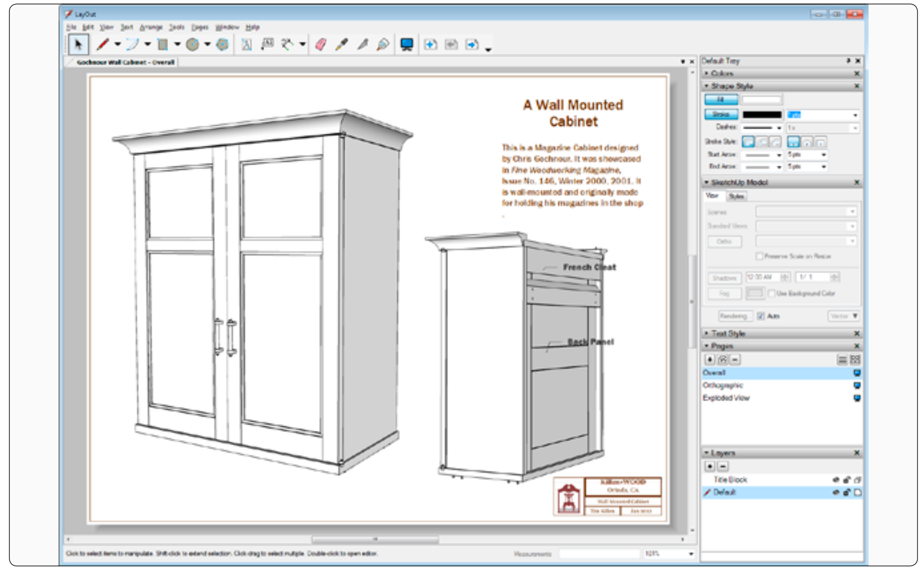


Figure 33. *The Layout screen with toolbar, dialog boxes, and the first page of the wall-mounted cabinet drawing.*

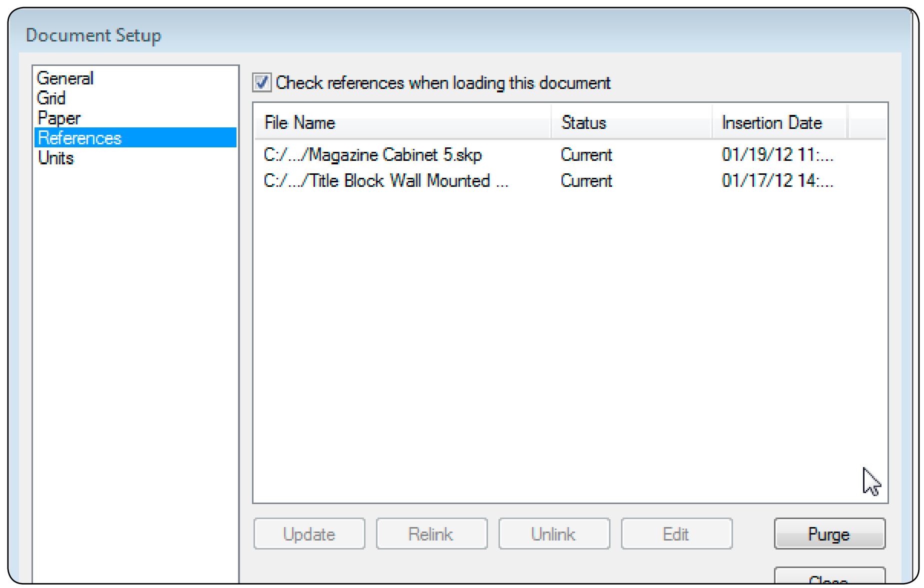


Figure 34. *The Document Setup dialog box in Layout showing document references.*

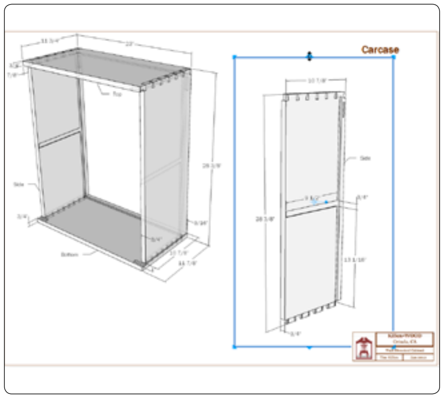


Figure 35. *Each scene is held in an adjustable frame, as shown for the carcase side.*

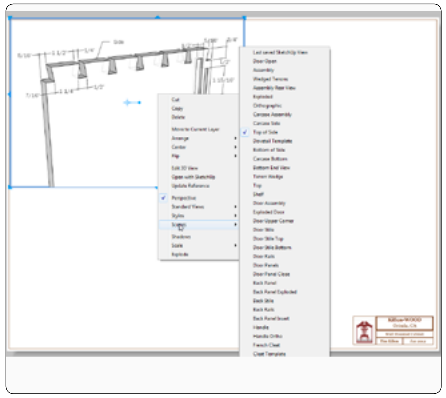


Figure 36. *Selecting a SketchUp scene to display in a Layout frame.*

For the wall-mounted cabinet, I've produced a one-page PDF that includes all the full-size templates (Figure 37). I've included the back panel stile and the door stile that fit comfortably within the 36-in. length of paper. There were no scenes within SketchUp showing the stiles in a Front View Parallel Projection. However, I was able to produce those views in Layout and display these templates.

To set the page size in Layout, open the Document Setup dialog box, as shown in Figure 38. By selecting Pages in the left panel, you can expose the selection box for paper size. A listing of options appears, as shown in Figure 38.

Figure 39 shows additional settings in the Pages option of the Document Setup dialog box. In the Rendering options, you have the choice of the Edit Quality or the Output Quality. I set both parameters to High.

Figure 40 shows the SketchUp Model dialog box within Layout. It allows you to set the Scene, Standard View, and the scale within Layout. When creating templates, I make sure that each component is set to Full Size (1:1).

This dialog box also has a tab at the top labeled Styles. Layout imports all the styles that exist in the SketchUp file. You have the option to switch styles in Layout, regardless of the choice you made when working in SketchUp. I sometimes use this feature to switch a component scene between Back Edges, X-Ray, or Standard.

Including a cutlist With a popular, free plug-in called CutList (available as a download at www.box.net/shared/ce18vpk36l), you can develop a cutlist based on the model components (Figure 41). Select the overall assembly of the model, click on the Plugins tab in the Menu bar, and choose CutList. A dialog box opens, allowing you to customize the output. I choose the option to produce a .csv file. Open the cutlist in a spreadsheet program and edit it as needed.

I save the edited cutlist as a PDF file and import it into Layout. You could also use .jpg or .png, but I find PDF to be a higher quality.

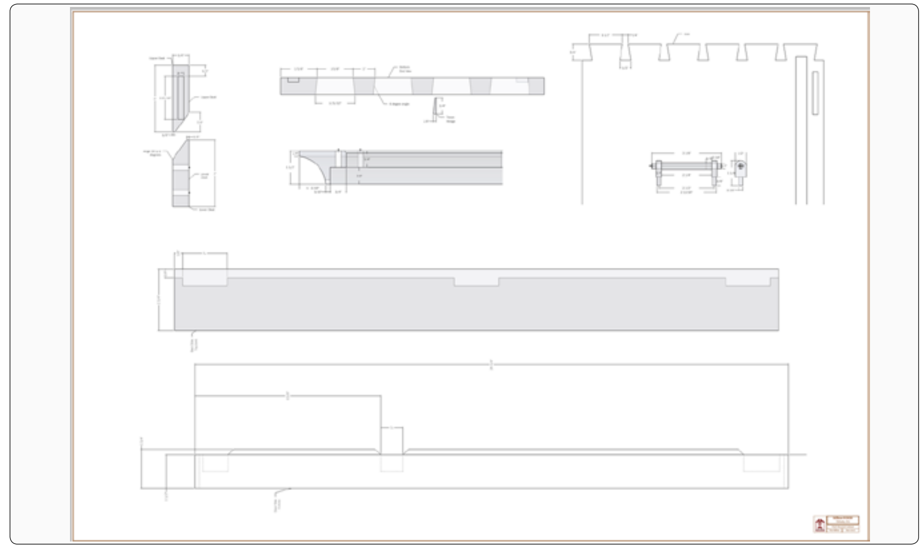


Figure 37. *The one-page Layout file printed on large paper. All of the full-size templates for the cabinet are arranged on this single page.*

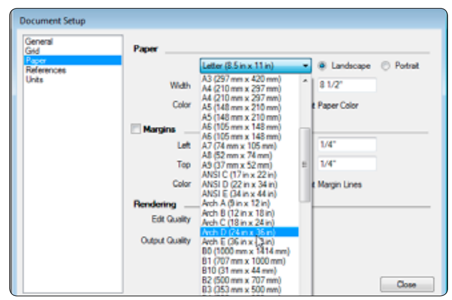


Figure 38. *The Document Setup dialog box in Layout showing paper sizes.*

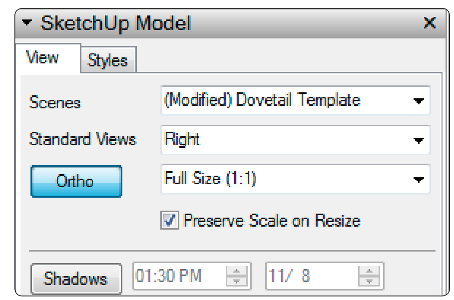


Figure 40. *Setting to Full Size (1:1) for templates.*

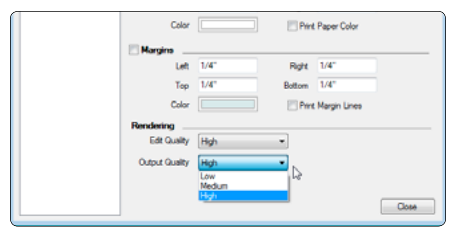


Figure 39. *Choosing High Quality Rendering.*

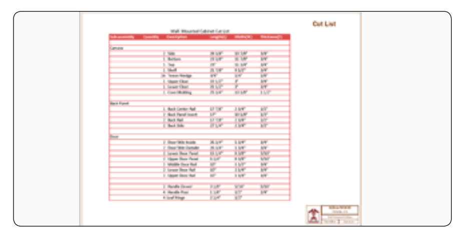


Figure 41. *The cutlist in the Layout file.*

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